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EDITORIAL.

THE ELECTRIC LIGHT.

THE wants of manufacturers, of photographers, and of those generally who either pursue some business occupation, or work of construction on the large scale, during the dark hours, or who make some special and direct application of light, are energetically demanding an abundant, concentrated, intense, and yet economical, source of light.

When we mention the first three requirements, our minds at once revert to the electric light, as we may perhaps have seen it produced by a powerful galvanic combination. But efficient as this may be, and satisfactory in the points first mentioned, it fails entirely (when developed by galvanic action) to fulfil the last but most important condition of economy.

This subject has been thoroughly investigated in all its relations by Mr. Eben Jayne, of this city, with whose valuable experiments, conducted for many years, we hope before long to make our readers acquainted. The general conclusion reached by this gentleman is, we believe, that where economy is a main point, the electric light produced by galvanic action cannot be profitably employed.

While arriving at this negative result in one point, however, Mr. Jayne has not failed to develop many positive facts and conclusions of great interest and value.

We must then rather look to some other source for the so desirable supply of the electric light-producing force.

There are two directions in which much has been done, and is now doing in this respect. 1st. With reference to the conversion of mechanical into electric force, as in the various magneto-electric machines. 2d. As regards the direct conversion of *heat* (without the interposition of mechanical force or motion of machines) into electric energy; as in the thermo-electric batteries of Becquerel, of Marcus and of Farmer.

As concerns the first of these, we need but mention the name of Wild, to recall to all our readers, those wonderful developments first published in this *Journal* last September, and since fully described in detail in our December number.

We look upon this as the most promising improvement yet made in the production of electric force, and although the Abbé Moigno, in a remark quoted in our last issue, mentions a difficulty which has been encountered in practice—from that heating due to what might almost be called "a friction of forces" which Tyndall has so beautifully exhibited in an experimental manner, by melting an alloy in a copper tube, rotated between the poles of a powerful magnet—yet we do not doubt that this will be easily surmounted.

This machine, as we gather from a statement in our admirably illustrated contemporary, the *Scientific American*, is to be put in operation by a company just organized in New York, and we shall look with great interest towards that quarter, for news of progress.

This is not, however, the last development in the above direction. Something more has been discovered, which, if not yet made effective in a practical form, points very clearly to great practical results in the near future.

We were amused, as no doubt were many of our readers, by a very preposterous account of evidently impossible discoveries made by Mr. Siemens, the well-known inventor of the gas regenerative furnace, which has been going the rounds of the unscientific and would-be-scientific press. We have intentionally forborne to quote and republish any of these statements, because we regarded our Editorial duties as including, among others, a moderate amount of seive-like action, by reason of which we should eliminate from our pages some

of the nonsense which diffuses itself with such admirable facility through our periodical literature, scientific and otherwise. We have now, however, in the *Chemical News*, just received the true version of the story, which, without transcending the bounds of possibility, is wonderful enough to excite our interest and reward investigation. We quote this therefore in full:

"The apparatus used in Mr. Siemen's experiments, consisted of two electro-magnets, coiled with long and thin wires, and between the poles of these electro-magnets an armature, also coiled with long and thin wires, was made to revolve rapidly by means of pulleys.

"When a voltaic battery was connected with the wires of the electro-magnet for a few moments, and afterwards disconnected, the residual or permanent magnetism of the electro-magnets was sufficiently strong to generate a feeble current of electricity in the wire of the revolving armature. The feeble current thus generated, was then transmitted through the coils of its own exciting electro-magnet, instead of the current from the battery, and by the mutual action and reaction of the electro-magnet, and the armature upon each other, the magnetism of the machine could be exalted to such a degree as to require the application of very considerable power to drive the apparatus.

"That this increase of magnetism was attended by an increase of dynamic electricity in the wires surrounding the armature and electro-magnet, was manifest from the brilliancy of the spark at the commutator and the increased deflection of a galvanometer needle placed within the influence of the electro-magnetic circuit; but the quantity of electricity was not sufficient to ignite wires, and was comparatively small in proportion to the mechanical force expended in producing it.

"The apparatus used by Dr. Wheatstone in his experiments, which was also shown in operation at the meeting, was very similar in construction, and identical in principle, with that of Siemens, though each of these experimentalists appears to have worked out his results independently.

"Instead of the long and thin wire used by Siemens in his machine, Wheatstone employed coils of thicker wires, and the wire on the electro-magnet was of the same diameter, and about eight times the length of that on the armature. The coils of the electro-magnet had consequently about eight times the resistance of the armature circuit. In this arrangement, the wire surrounding the armature being the generating circuit, it follows from a well-known property of the electric circuit, that the amount of dynamic or useful effect which the current is capable of exerting when the resistance of the coils of the electro-magnets is in circuit, is about one-ninth of the total amount which the armament coil is capable of evolving, when the electro-magnet is excited to the same degree by a separate battery or other electro-motor.

"This peculiarity of the machine was made evident by Dr. Wheatstone, in a very striking manner, by means of the following well-devised experiment:—Two branch wires were led off from the extremities of the armature coil, and when the electro-magnet was fully excited, the free ends of the branch wires were bridged across by means of a fine platinum wire about nine inches in length, which wire immediately became white-hot, and as suddenly ceased to be visibly hot until contact with the branch wires had been broken for a short time and afterwards re-established.

"This momentary ignition of the platinum wire appeared to Mr. Wilde to be due to the diversion of the greater portion of the current generated by the armature into the new channel or short circuit established by the platinum wire through the armature coils, before the high degree of magnetism which had been maintained in the electro-magnet by the full current from the armature, had been reduced by the loss of a portion of the current so diverted.

"The results obtained by Siemens and Wheatstone are undoubtedly very interesting from a scientific point of view, but, practically, the exciting of the electro-magnet by the current from the armature used in connection with it, produces results very inferior to what are obtained from similar machines, the electro-magnets of which are excited by a separate source of electricity of small power, as, in the latter case, the full force of the current generated by the armature coil is available for the performance of external work.

"Mr. Wilde having himself, some time ago, made some experiments similar to those of M. Siemens and Dr. Wheatstone, came to the conclusion, that, in the present state of our electrical knowledge, the difficulty of utilizing the current from the armature, after it had passed through the coils of the electro-magnet was insuperable; as it is absolutely necessary that the coils of the electro-magnets of electro-magnetic machines, when excited by intermittent currents, should be of considerable length, in order that they may acquire and retain a charge of electricity or magnetism, as has been shown by Drs. Henry and Faraday in their experiments on the induction of a current upon itself. On the other hand, for the production of powerful electro-dynamic effects, it is necessary that the wire of the armature coil should be comparatively short and thick. Hence the incompatability of the armature and electro-magnetic circuits, when exalted dynamic effects, outside the machine, are required.

"It is not a little interesting to observe, how, in the progress of physical science, the same train of reasoning is often pursued by several individuals having no communication with one another. In the present instance, it would appear that the 'augmentation of the power of a magnet by induction currents produced thereby, and reacting upon the magnet itself,' has also suggested itself to other experimentalists besides M. Siemens and Dr. Wheatstone. In a letter published in the *Engineer* of July 20, 1866, p. 42, the writer (Mr. J. Murray) says:—'The description in recent numbers of the *Engineer*

of Mr. Wilde's admirable improvements in the magneto-electric machine, induces me to point out, if you will permit it through your columns, a variety of the principles embodied in his machine, which is so obvious that it cannot fail to be hit upon, by some inventor before long.'

"It is briefly this:—'Whereas, Mr. Wilde, beginning with an ordinary magneto-electric machine, uses the current obtained from it to charge a powerful electro-magnet, and from this obtains a second and more powerful current, which, used in like manner, produces one still more intense, I, using only a single machine, pass the current obtained from its armatures through wires coiled round the permanent magnets, in such a direction as to intensify their magnetism, which in its turn, reacts upon the armatures and intensifies the current.

"'It is obvious that the amount of mechanical force which can thus be converted into electricity is only limited by the capacity of the iron for magnetism; just as the power of a steam engine is only limited by the capacity of the boiler for absorbing heat.'"

"Mr. Wilde has also received a letter on the subject of his recent experiments in magnetism from Mr. Moses G. Farmer, of Salem, Mass., United States, dated November 9, 1866, in which he says, that he had obtained an increase of 31 per cent. in the power of a magneto-electric machine, by transmitting the current from the armature, through coils of wire surrounding pieces of soft iron forming the prolonged extremities of the permanent magnets of the machine. Mr. Farmer, in the same letter, adds:—'I have built a small machine in which a current from the thermo-battery excites the electro-magnet of your machine to start it, and after the machine is in action, a branch from the current of the magnets passes through its own electro-magnet, and this supplies the magnetism required. It is not exactly like a person standing in a basket and trying to lift himself—because the electricity proceeds from the conversion of the mechanical energy, which must be continually supplied. Neither can it in any wise be likened to the various schemes for producing perpetual motion; but depends on the principle that the actual energy of the mechanical force, conjointly with the potential energy of the magnet, can develop a greater amount of potential energy than is originally resident in the magnet, or, in other words, it is a method of converting part of the actual energy of the prime mover, into the potential energy of magnetism.'"

The discovery of these facts undoubtedly opens the door to many new and important results.

With regard to the second method of obtaining electricity, that by direct action of heat, much has been done of late years; but the improvements yet made, though securing an immense advance upon previous attainments, have not brought this source of electric power up to the level of practical applicability.

Mr. Farmer, of Boston, mentioned above, has gone the furthest, we believe, in this direction, and with his thermo-electric batteries, somewhat resembling, in shape at least, the cylinders of ordinary stoves, and filled like them with burning coal, produces some sort of continuous electric light; but he has made no publication of his results, and what is above stated is only from report.

As regards the application of such electric lights as we possess, to practical purposes, much is being done. Thus we learn from the Abbé Moigno, that the electric light of the Alliance Company is installed on the yacht of the *Prince Napoleon*, where it will be employed in experiments as to the possibility of thus illuminating a distant coast, fort or vessel. Experiments are also in progress on the the East Railway of France, with a view of lighting depots, and tunnels in course of construction, and, as we noticed in our last issue, one of these lights has been employed in the shops of the North Spanish Railway.

NEW INVENTIONS.

At the last meeting of the Franklin Institute, there were exhibited a number of new inventions and improvements, some of which are of sufficient value to deserve a descriptive notice.

An improvement in surveying instruments, of great practical value was exhibited by Mr. F. Seelhorst, of this city. This improvement consists in an arrangement, by which the draw-tube of a small telescope may be adjusted in a manner analogous to that employed in moving in or out the point of a pencil case, and without the use of the rack and pinion commonly employed. The advantages claimed are as follows: 1st. the tube being always covered will be less liable to corrosion and sticking. 2d. The instrument relieved of its pinion head is less liable to catch when carried through underbrush, &c. 3d. The apparatus is stronger than the rack and pinion, because bearing on five screw threads in place of a single tooth.

A car break for the entire train, under the control of the engine driver, by S. McCambridge. In this arrangement a barrel is, by the action of a lever, thrown in gear with the driving axle of the locomotive, and winds up a chain which is practically continuous throughout the train. Under each car this chain passes over a fixed

pulley, and is returned over a movable one at the end of a bell-crank lever, which actuates the system of breaks for that car. By this means a given strain brought upon the chain, repeats itself equally on each car, thus giving an immense aggregate effect without excessive tension at any point.

The advantages of such a system are many and obvious, among which especially may be considered this: That the entire control of the train being in the hands of the engineer, he may *instantly* "break up" his train in a case of emergency without waiting for any secondary action of others; and, it being easy for him, at any moment, to relieve the brakes, after putting them on, he will be the more likely to use this as a precautionary measure in cases of *threatened* danger, where he might otherwise prefer a risk to the necessity of an entire stoppage.

An improvement in valves, by Thomas Shaw. This consists in fitting a slightly conical or tapering valve to a cylindrical seat, by cutting a fine screw thread upon each, the same thread being continued upon the stem of the valve, and forcing it into its seat. By this means a perfectly tight valve is produced with little labor, and nicety of adjustment. The principle involved is precisely that applied in all hydraulic fitting, where tapering pipes are screwed into cylindrical holes, and make perfectly tight joints, but the present application of it is ingenious and effective.

A gauge-cock whistle was also exhibited by Mr. Shaw, which is intended to be attached to any ordinary gauge-cock, and will, when the cock is open, produce a whistle-sound if steam escapes, a bird-like note with foam, and no sound with water. By this means, not only is the engine-tender enabled more certainly to know the state of the water in his boiler, but the whole establishment are likewise notified of the same fact whenever he opens the try-cocks.

ENGINEERING ITEMS.

Making a new river and tunnelling an old one.—We have received the following very interesting particulars from Prof. De Volson Wood, of the University of Michigan, who moreover promises us more of the same sort:

"About two months since, I was at Joliet, Illinois, and saw them

working on the Michigan and Illinois Canal. They are deepening it, so that canal boats can float out of Chicago river into the canal, thus avoiding a lock at Chicago, and also causing a current in Chicago river. To do this, they excavate through solid limestone, about ten feet deep, for about eight miles. The expense is paid by the city of Chicago. The primary object is to improve the Chicago river, a work much needed, and one which will undoubtedly be secured by the plan adopted. It will take two years more to cut through the rock.

"I was there but a short time, on a stormy day, or I would have learned more of it. I learned, incidentally, that it would cost Chicago about $1,500,000, but the information was not official.

"I have also learned, but not officially, that the Legislature of Illinois has voted $5,000,000 to make a ship canal from Chicago river to, and down the Illinois river.

"The city of Chicago is tunnelling Chicago river where it is crossed by Washington street. This will be a great relief to the business community. The business on the river is so great that it keeps the draw bridges on the move almost constantly in the summer time. Doubtless the river will be tunnelled in several places in a few years."

Pennsylvania Steel Company's Works, at Baldwin, near Harrisburg. We were present last Wednesday at the visit of inspection made by the stockholders of the above company to their now nearly finished works for the manufacture of Bessemer steel. Within the narrow limits now at our disposal, it would be quite impossible to make any full description of these works, but, at a future occasion, we hope to furnish a full account. During the visit above named the various machinery was put through its motions. The huge converters turned over with the combined deliberation and ponderous grace of learned elephants, standing on their heads; the hydraulic lifts glided up and down, the blasts from the blowing engines, roared like a whole menagerie of wild beasts, the various pumps pumped as became them, and everything else was in most satisfactory order.

Among the visitors were the following: S. M. Felton, President of the Steel Company, George A. Parker, C.E., Isaac Hinckley, Henry G. Morris, Edward Y. Townsend, Joseph B. Townsend, John Clayton, John Brown, Percival Roberts, Dr. Spooner, Edward Miller, C.E., Major Henry McAllister, Jr., Ellis Yarnall, Robert H. Lamborn, Wm. Sellers, Wm. B. Bement, Chas. Potts, George G. Lobdell, Edward Hoopes, Dr. Le Conté, Henry R. Worthington and D. A. Hines, of New York, Hugh E. Steele, Messrs. Tatem Bros., Dr. Huston, Wm. Colder, W. Q. Hickok, Mayor of Harrisburg, Charles Hartshorne, Mr. Dimpfel, Thomas Arnold, Charles S. Hinchman, Henry Gilbert, Esq., Aaron Bombaugh, G. Dawson Coleman and others.

Civil and Mechanical Engineering.

(Continued from page 238.)

THE NEW YORK "CENTRAL PARK."

By WILLIAM H. GRANT, Superintending Engineer.

CHAPTER II.

PRELIMINARY AND FOUNDATION WORK IN GENERAL CONSTRUCTION.

PRELIMINARY to the construction of the Park roads a thorough survey of the grounds was necessary, and a careful location of the roads as to lines of direction, curves, grades, etc.

The proposed position of the roads as indicated by a general outline plan was the first point for consideration, as it was necessary to determine, by a careful investigation of the ground, how far it was practicable, with due economy, to conform to such a position. This involved the mapping out of the ground, leveling and making cross-sections and computations of the quantities of cuttings and fillings. More than usual care and labor were required in this work, in consequence of the general rugged character of the ground, the prevalence of rock above the surface and hidden at various depths below the surface, and the considerably more than usual breadth of ground occupied by the roads.

The problem was frequently complicated by other circumstances, such as the crossings of bridle roads, traffic (or "transverse") roads and walks, which were to be passed by bridges either over or under the proposed line of road.

Comparative lines and modifications were necessarily considered, surveyed, plotted out and estimated. When this was done and the best compromise practicable made in the selection of the position of the roads, it was next necessary, where surplus material resulted from the excavations in grading, to find a place where such material could be turned to account and utilized in some other portion of the general work of improvement. In like manner, where a deficiency of material resulted from the excavations to fill the depressions, the site had to be sought on adjacent grounds, whence such deficiency could be made up or "borrowed," and at the same time develop if possible, or at least not detract from, the natural features of the ground selected.

The desideratum was, of course, as in all cases of roads, railroads, canals and similar earthworks, to equalize cuttings and fillings. This process was perfected by modifications and re-adjustments of the grades from time to time, as found practicable after the general location was made, and also by slightly swaying the line of the road laterally, one way or the other, along steep sidehill ground, so that the portions of earth and rock lying above the grades, including the necessary side slopes, would, when excavated and removed, just fill up the intervening hollows lying below the grade-line.

Where there are no restrictions as to the acclivity of the grades of a road and the shortness of curves to be adopted, or as to the position laterally that the road is to occupy, this problem is greatly simplified and admits of a comparatively easy solution. But in the case of the Park roads, it had been decided after a general study of the adaptation of the ground, to limit the maximum grades of the roads to one foot rise in a distance of twenty feet, and to make the curves large and sweeping, so as to admit of the easy turning of vehicles at brisk rates of driving, and of seeing a safe distance ahead; the position of the roads, laterally, was also restricted in most cases, to quite a moderate breadth of ground. Hence it will readily be understood, especially by engineers, that a judicious location of the roads with reference to proper economical considerations, was no light task.

GRADING.

The location of a section of road having been made, the ground was staked out, and the depths of cuttings and fillings marked &c., and the work of excavating, grading and preparing the road-bed for the reception of the road material or superstructure, was then proceeded with. Care was taken in making the deeper fillings, to compact the materials so as to prevent subsequent settling and derangement of the work when the road was finished. All surface-soil, muck and vegetable or perishable matter were removed from the surface in advance of the filling; wet spongy ground was also excavated a proper depth to make room for better material. If surplus stones were afforded by the excavations beyond what were wanted for the road materials, or if the stones were of unsuitable quality for other work, they were deposited in such places and in such positions in the fillings, as were best calculated to facilitate the drainage and give firmness to the road-bed. When large stones and masses

of blasted rock were used in the fillings, care was taken to fill the interstices between them with smaller stones and earth.

The filling was carried on in this way in horizontal layers, until it reached its full height, advantage being obtained as far as practicable during the operation, of the travel of teams and carts over the successive layers, to aid in compacting the material. The filling was evenly shaped at the required height or "sub-grade," a crowning form being given to it transversely of the roadway, corresponding with the intended crown of the surface of the road when finished. The best material was selected from the excavations, for the last or surfacing layer, such as gravel, gravelly or sandy loam, or gravelly clay, as the case might be, and this, after the proper shaping, was firmly and uniformly rolled by heavy cast iron rollers drawn by two horses. Any inequalities or depressions occurring during the rolling, were filled up with fresh material, and the surface kept true to the sub-grade line longitudinally, and to the curved or crowning form transversely. The excavations were sunk generally to the same sub-grade line that the fillings were raised to; if in earth that was not deemed suitable for the road-bed, they were sunk somewhat deeper, and the additional depth was refilled with better material, as before stated. In rock excavations, the rough irregular depressions at the sub-grade depth of the road that were caused by blasting, were filled with small stones and chips, in such a way as to keep the drainage free from the middle of the roadway to the side drains, and as far as practicable, outlets were given to all the deeper cavities of the rock, to prevent water from standing in them.

The road-bed was crowned, adjusted and rolled, after the drainage was perfected, in the same manner in the excavations as on the fillings.

Generally, before the completion of the surfacing process of the road-bed, the necessary trenches were dug for the "surface" and "sub-drainage," and for the water-pipes that were laid alongside the roads, the drains and pipes laid down and the trenches refilled.

DRAINAGE.

After a firm foundation has been secured to build upon, the next important step in good road-making, is drainage. Without a firm foundation no art can achieve a successful superstructure, and without thorough drainage no superstructure, however well founded and otherwise skilfully built, will long resist the severe effects of our

climate. Frost is a most destructive agent to roads and walks. It can only be resisted by depriving it of the means by which it acts—wet and moisture. Water retained in the soil or in the materials composing a road, soon produces deteriorating effects. The foundation is liable to settle unequally, displacing and deranging the materials above, and the surface of the road will wear away more rapidly by attrition, when saturated, producing alternately mud and dust. When the water is acted upon by frost, it will loosen and heave up the best road, and undo in a short time all that the appliances of art, in the use, disposition and manipulation of the best materials, have accomplished. Therefore it is held, that upon the thoroughness of the manner in which the drainage of a road is performed, and its successful operation, will depend the permanence of the work.

Road drainage is of two kinds, sub-drainage, or under-drainage, and surface-drainage. Sub-drainage applies to the disposal of water that finds its way to the road-bed below the road materials, and into the ground forming the road-bed and immediately adjacent.

Surface-drainage applies to the rain-fall and water from melting snows and other sources, received on the surface of the road and side slopes, and to the mode of conducting it away before it enters the ground or accumulates in too great a volume.

1st. *Sub-drainage.*—Where the roads were laid on fillings or "made ground," the nature of the materials was generally such as not to require special sub-drainage; where they were laid on or very near the natural surface of the ground, and on excavated ground, which constituted the larger portion, sub-drainage was essential.

In rock excavations the mode of drainage of the road-bed has been in part indicated. In both rock and earth excavations, side trenches were excavated, following nearly the lines of the road gutters, for the reception of drain-pipes for both sub-drainage and surface-drainage, and also for the water distribution pipes of the Park. The latter pipes occupy but one side of the road, branch pipes being laid from them where necessary across the road, to supply hydrants on the opposite side. In rock excavations, to save expense, the water pipes, surface-drainage and sub-drainage pipes on one side of the road, were all laid in one trench, and on the opposite side of the road the sub-drainage and surface-drainage pipes were also laid in a single trench.

In earth excavations and in crossing fillings or made ground, the

water pipes are laid in a separate trench from the other pipes. At intervals of about three hundred feet along the roads, "silt basins" are constructed (as will be hereafter described) on each side of the road, into which the sub-drainage pipes discharge, and the water flowing out of the basins is conducted through a short branch pipe, into the larger surface-drainage pipes. The sub-drainage pipes, in consequence of their discharging at these short intervals into the silt basins, are not required to be large, and are composed of common drain tiles of 1½ to 4 inches bore. They are laid at a depth of three to three and a half feet below the surface, with an inclination of, generally, not less than one foot in one hundred feet of distance. The manner of laying them is the same as that adopted in the general sub-drainage or agricultural drainage system of the Park, which is as follows: The separate pieces of pipe are carefully and truly placed on the bottom of the trench, with their ends in contact; a "collar"—which is a short section of a larger sized pipe—being slipped over the joint, or a "saddle"—which corresponds with about the half of a collar divided longitudinally—is laid over the joint to prevent dirt from entering or being drawn in by water. The collar is preferable to the saddle, as it is the more effectual safeguard against the joints of the pipe or the pipe itself, being choked with earth. The drainage water gathering in the bottom of the trench, finds its way freely, in all ordinary cases, through the slight annular space (the collar fitting easily but not too loosely) between the pipes and collar, and through the inclosed joint into the pipe. The roughness and inequalities of the ends of pipes, although in contact, afford sufficient openings for the water to percolate through, and the frequency of the joints (about twelve inches apart) gives room for the admission of water in no great length of pipe, equal to the capacity of the pipe to carry safely. The covering of the pipe with earth is done with care, a light layer of selected material, free from stones and lumps, is first packed around and over it so as to cause no derangement of joints, and the balance of the trench is then refilled and thoroughly rammed, to prevent as far as possible, any future yielding or sinking away of the earth.

The pipes in the side trenches of the road extend in this manner from one silt basin to another, starting a few feet in advance on the down-stream side of one basin, and extending to and entering the next one in the descending series. Lateral or branch drains are laid from these drains, running obliquely in the ascending direction, to

the middle of the roadway, and are placed at greater or less distances apart, according to the circumstances of the ground. These lateral drains are composed of smaller tiles than the side drains; sometimes instead of tiles, cobble or small quarry stones are used, and in such cases a shallower trench is dug than for tiles, the trench being from fifteen to eighteen inches deep below the sub-grade of the road, and of a width about equal to the depth. The trench is filled with stone or with stone and coarse gravel, to the surface, and a communication is made at the lower end of the drain with the side or main drain running parallel with the road, by a short piece of pipe, having one end fitted into the side drain and the other end extending into and surrounded by the stone or gravel. Drains of this kind are sometimes called "mitre drains." Sometimes, where more than ordinary precautions are necessary for draining the road-bed, the tiles for the lateral drains are covered with coarse gravel or rubble stones in place of earth, and the trench is partially or entirely filled with the same material. The main side-drains are also occasionally treated in the same manner.

This method of sub-drainage was applied more particularly, in the detail in which it is here described, to the wider roads of the Park that were earliest constructed, the widths being from forty to sixty feet. For the roads of less width later constructed, the process was somewhat modified. The side-drains, by being brought closer together (by the less width of the roads), rendered, on most ground, the lateral or mitre drains of the road-bed unnecessary. Considerable portions of the narrower roads (thirty-three feet wide) were laid on "made ground" that was composed largely of blasted rock and stone filling, and therefore needed no additional sub-drainage of any kind.

2d. *Surface-Drainage.*—The surface or superficial drainage of roads is quite different in character from the sub-drainage, but is not the less important. Its object is in part, to relieve or assist the sub-drainage by disposing of water that would otherwise, to more or less extent, filter into and saturate the ground, but mainly, its purpose is to guard against the sudden gathering of water in large volume, and the gullying of the ground along the road, or sweeping away or abrading the road material. To illustrate the necessity of such a provision, it is only necessary to recur to some well-remembered instance—within the experience of most persons—of a country road where the effects of showers of rain have been seen in the deep and dangerous gullies formed by accumulations of water following a long

distance in the line of what was once, perhaps, intended for gutters, without any escape or outlet.

The first element to be considered in a proposed system of surface-drainage, is the amount of rain-fall to be provided for, and the next step is to devise the most practical and efficient means, with a due regard to economy, by which to attain the desired result. The mean annual amount of rain-fall, including melted snow, as furnished by meteorological tables, is not a safe guide, the extremes only (that are not generally recorded) of rain-fall in the shortest spaces of time, furnish such data as is necessary for the object. This, however, if accurately ascertained, can only be taken approximately, and must be very much modified by a variety of circumstances. It would not be practicable to give to any artificial system of drainage, such a capacity as would meet emergencies that arise at widely occurring and uncertain intervals of time, as the great expense of such a system would, in all probability, surpass the amount of injury that might be done through the inadequacy, at such a juncture, of a modified plan. We do not find in the economy of nature, works of an hydraulic character upon so extended a scale as this. Rivers sometimes overflow their appointed channels, and flood plains and valleys; and rivulets that course down mountain slopes for years together in capacious and well-worn beds, are occasionally swollen in so unusual a manner as to break over and abrade away their strong and rocky barriers.

Where Providence does not provide for extreme elemental contingencies, it would scarcely be wise for man to attempt to do so.

A practical mean has to be found somewhere between the occasional or ordinary, and the remote or contingent extremes of rain-fall before settling upon the practical capacity of drainage works. This point received a good deal of attention in connection with the roads and the general subject of the surface-drainage of the Park. All available information and examples were consulted, but no special rule could be deduced, past experience and practice having settled at most, only general principles, leaving the formulæ applicable to any particular case or locality, to be worked out according to individual judgment and the peculiar attending circumstances. The nearest approach that has been made to definite rules and unanimity of opinion, is in the drainage of cities; but here, even, differences exist that are not easily reconcilable. Besides, the circumstances are so different in the two cases of city drainage and open land

drainage, that a rule, however clearly established in the one case, would not safely apply in the other.

The question was settled as regarded the Park roads, by deciding upon such a provision for the drainage as would safely dispose of an amount of surface-water equal to a rain-fall of two inches in depth in the space of one hour. It is rare that such an amount of rain falls in this part of the country. No recorded instances have been met with of rain to that extent in the vicinity of the city of New York. The only instance that is known to be reliable, occurred on a part of the Central Park grounds on the 13th day of July, 1859. The quantity of water that fell at that time in the space of half an hour (within a fraction), was two inches, as ascertained by a rain-gauge that was kept by the engineer department. It occurred during a heavy thunder shower, the violence of which lasted but little over the half hour, and which was evidently very local in extent. The amount of water was very unusual, being just double what it had previously been decided to provide for in the drainage system, and it would have been alarming, had it not been known to be unusual and exceptional.

The portion of the Park grounds upon which the most of the shower appeared to fall, had not, at that time, been much broken up or disturbed by the progress of the various works of improvement, and but little damage was done by the water.

No similar rain storm has occurred on the Park since that time, nor has a quantity of rain since fallen, it is believed, at any one time, equal to two inches depth in one hour.*

Had the drainage works of the Park been fully completed, together with the roads and other works of improvement when this storm occurred, it is not imagined that very material damage would have been done. Some injury would doubtless have been sustained by the roads, by the overflowing of gutters and washing off of the surface materials, and temporary ponds might have been formed in depressed portions of the grounds, but nothing more serious would have been likely to have occurred by a shower that was *so limited in its range and duration.*

(To be continued.)

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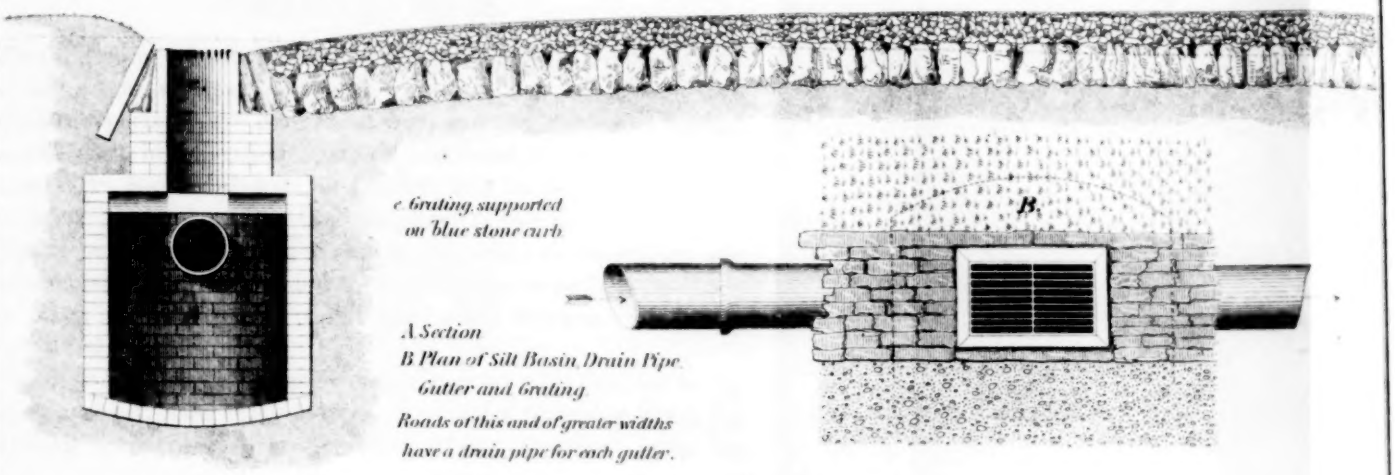
* The Croton Aqueduct Department report "an extraordinary rain-fall in the city of New York, in October last, of upwards of four inches in about five hours."

Half Section of Telford Road 45 feet wide

Scale 1/36



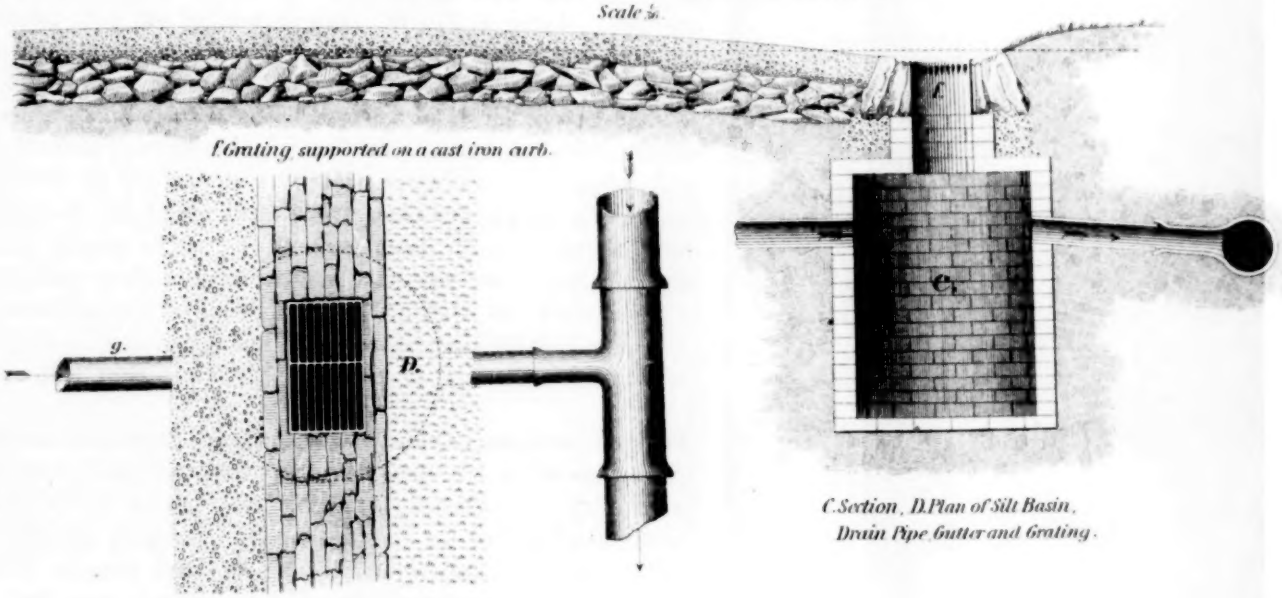
e. Grating supported on blue stone curb.

A Section
B Plan of Silt Basin, Drain Pipe, Gutter and Grating.

Roads of this and of greater widths have a drain pipe for each gutter.

Half Section of Gravel Road 33 feet wide

Scale 1/8



f Grating supported on a cast iron curb.

C Section, D Plan of Silt Basin, Drain Pipe, Gutter and Grating.

g. Drain pipe from Silt basin on opposite side of road. This arrangement applies to the narrower roads having but one longitudinal or main drain pipe.

W.B. Swan. del.

PERMANENT WAYS.

THE following paper, descriptive of some recently tried plans for dispensing with wooden sleepers on railroads, and substituting iron for all the parts of the permanent way, and the discussion on the material used in construction, which succeeded its reading at the rooms of the Society of Arts, in London, will be found particularly interesting by the American Civil Engineer at this period.

The recent prosperity of the various corporations controlling our most important lines, has placed their exchequer in such a condition that many structures of a costly and solid character, are being planned and built.

The desire to reduce operating costs, even at some expense to the interest account, leads every inquirer to consider favorably plans for increasing the perfection or durability of the structure under his charge.

No part of our American railroads is perhaps open to more improvement than the permanent way. Within a decade, however, we can mark a great advance from the narrow strap-rail laid on wooden stringers, such as was in use on the Virginia Central and other roads. This was succeeded in many localities by the light T rail with its thin rattling chair, placed on a single tie, which was in turn followed by the heavier sixty-four, sixty-seven and eighty-five pound rail, with fish joints, braced with wood and placed on two ties, that is still largely in use on our best lines. This system is in its turn giving way to the magnificent superstructure such as the Lehigh Navigation Company is about to lay down, and the Pennsylvania Railroad Company is engaged in laying—composed entirely of heavy Bessemer steel rails, carefully jointed with well-secured wrought bars.

The direction in which our contemporaries in Germany and England are progressing, may be partly gathered from the following paper. The experience of the German roads in this direction, is all the more valuable because they use a section of rail not very different from that chiefly adopted here,—the flat-footed or American rail. The facts set forth may also be useful because they describe a superstructure entirely composed of iron, which in some modified form will in a future period be found most expedient for use on the vast woodless plains of the west and south-west.

From the London Journal of the Society of Arts, No. 740.

THE IRON PERMANENT WAY IN USE ON GERMAN RAILWAYS.

By T. A. Rochussen, C.E.

The system of making railways, by levelling a layer of ballast and forming an upper-structure of wooden sleepers, cast-iron chairs, topped with a wrought-iron rail, and held together by a wooden key, has, for a great number of years, appeared to German engineers to be unworthy an age in which the manufacture of good iron, and its composition into an efficient bearing system, are far better understood than thirty years ago, when the importance of railways as the principal arteries of our social and commercial intercourse was only just foreshadowed.

While locomotives and rolling-stock had, in their construction and performance, progressively represented the advance of practical science, and embodied the genius of the designer, the care of the builder, and the aptitude of the worker in metal, to provide for all the requirements of traffic, it was felt in Germany as well as elsewhere, that the time had arrived to apply the same intelligence to permanent way; and that it had become necessary, as much as possible, to reduce the variety of material, and to avoid that most liable to perish, like wooden sleepers or cast-iron chairs, alike destructive to the wood below and the wrought-iron above; and finally, to get rid of the crude contrivance of fixing rails by means of wooden keys. For this reason, the double-headed rail, copied from English precedent, has enjoyed little favor in Germany, and where adopted, is gradually superseded by the more general practice of flat-bottomed rails, with or without bed-plates on the sleepers.

The failure of Barlow's permament way (perhaps a great deal owing to the use of inferior material) unfortunately discouraged railway directors from pursuing or sanctioning experiments in the right direction, and jeopardizing dividends. While, therefore, different scientific papers published a number of schemes for the construction of iron permanent way, some patented, others given away *pro bono publico*, and all of them eagerly discussed at the meetings of practical engineers, the first step to realize a project was only made at the end of the year 1863, by putting in hand the different systems herewith illustrated, some of which came into actual use in the beginning of 1864, others in 1865.

The theory which guided these constructions, may be summed up as follows:

The nearest approach to perfection in a permanent way, is to present to a moving load a sufficient, an unmoveable, continuous, and even resistance, as the only means of obviating the oscillation and thumping of fast trains.

Although the weight and height of the rails have been steadily increased, in order to spread the rigidity of the line over a large number of cross-sleepers, there remains in practice an unavoidable deflection of rail between the points of support.

The bending down of the sleeper-end, taking place during the passage of the engine and the oscillation of the carriages or trucks, especially with old or soft wooden sleepers, sufficiently shows that the pressing load is not spread equally over the whole length of the sleepers, and is not evenly supported for the entire length of the wheel base, but that the chair, or point of support, receives a succession of blows, with the whole weight of the load resting on the axle.

If, therefore, we could devise a longitudinal way, possessing sufficient rigidity to transmit the pressure of the load over a large bearing surface, we should avoid the wave-like motion occasioned by the cross-sleepers.

This resistance to pressure can be obtained in a simple ratio, by increasing the flat base resting on the ballast, or, more economically, by increasing the height of the rail, since the power to support grows in the square ratio of the height.

The boldest and simplest plan of iron permanent way under consideration, was that advised by Mr. Hartwich, engineer of the Rhenish Railway, and laid down on the right bank of the Rhine, between Coblentz and Oberlahnstein on a perfect level, and also between Mechernich and Enskirchen, the latter an incline of 1 in 70, and on a curve of 800 yards radius.

The ballast, always an object of especial solicitude with Prussian engineers, is of broken flint, and laid in a channel three feet broad at the top, shelving down to one foot, and eighteen inches deep. The rails shown in section A (see Fig. 1) eleven inches high, weighing 115 lbs. per yard, with a flat bottom of four inches, are placed immediately in contact with the ballast, and sleepers or bed-plates are dispensed with. The space between the rails up to the middle of the head, and also the clear way outside the rails, are filled with fine gravel, tightly rammed in.

The rails are fished vertically and horizontally, as the rail of section B, nine inches high, which has since been ordered to the extent of fifteen miles, on the line between Kempen and Kaltenkirchen, and its adoption is likely to extend with the growth of Rhenish railways to the exclusion of the eleven-inch rails, which were found unnecessarily heavy and expensive. These rails are nine inches high, with a flat bottom five inches wide, weighing 85 lbs. per yard; the head, down to one inch of the web, is formed of steel, the web of fine grain, and the bottom of fibrous iron.

The vertical fish-plates, eighteen inches long, have two rows of fish-bolts for each rail-end, and to increase their stiffness have a longitudinal rib, resting against the web of the rail. The horizontal fish-plates, also eighteen inches long, are eight inches wide, and their connection with the rail is established by means of a cramp-plate, held between the nuts of the fish-bolt, and bearing upon the base of the rail. The use of this cramp is principally to allow a greater width of fish-plate, and to protect it against buckling up by the pressure of the rail. The rails are held to gauge by one-inch round bars, placed three

feet apart, the ends of which are provided with a screw-thread, nut, and washer, at each side of the web, so as to allow an easy adjustment of widening or narrowing the rail distance to the proper gauge. Alternately, the cross, or gauge bars, are put either three inches from the top of the head or three inches from the bottom of the rail.

The whole weight of the system is 145 tons per mile per single line of way; the contract price all round being £13 15*s.* per ton; or, exclusive of ballast and laying down, £1985 per mile.

The engineer reports: "Since June, 1865, the double line from Coblenz to Oberlahnstein and the Mechernich line have been worked with tender-engines weighing 37½ tons; no alteration has taken place in the level of the way, and the rails have nowhere worked into the ballast. The gauge has not in any instance been disturbed, the repairs of packing have been very trifling, and far less than on the line with cross-sleepers. The whole length forms a continuous, unmovable railway; and although there is a little bending at the fish-joints, this inconvenience is imperceptible compared with the advantages of the whole system. The filling of the rail space with gravel provided a more efficient security against sliding than the dogs and bolts in the wooden sleepers. The motion on the rail is perfectly free from oscillation and thumping; the noise of the passing train has a deep rolling sound, and although some passengers, who are acquainted with the peculiarity of the construction, pretend that the line is hard, the difference is not noticed by the majority of travelers. Whether the rigidity of these high rails will be more detrimental to themselves than the constant bending on cross-sleepers, time will have to show. If this disadvantage should manifest itself, it could be met by increasing the elasticity of the springs; on the other hand, the rigid surface offers a saving of traction power and wear of wheels, considering that with rails bending between sleepers every wheel practically runs on an inclined plane. It may be urged that, if once the rail heads should be worn out, the whole system will require renewal, but as an extensive experience with steel headed rails in Prussia, during 14 years, has shown that the life of a good rail, even under very onerous circumcumstances of traffic, is about 21 years, this objection falls to the ground, the more so since the rails of the present day, on wooden sleepers, have already reached the same weight per yard as our whole system without sleepers."

In the beginning of the year 1864 the Hoerder works, in Westphalia, supplied the Brunswick Railway with the two systems of iron permanent ways represented by Figs. 2 and 3, each of about 1100 yards in length, and some time afterwards with another variety of the same system, represented by Fig. 4.

The two first are lying side by side on the distance between Brunswick and Wolfenbuttel, that portion of the main line from the west to Berlin on which the wear of oak sleepers and the general repairs of the permanent way had been the heaviest of the whole distance between Cologne and Berlin.

The three systems embody the principle of supporting the head of the rail between the vertical arms of two angle-bars, riveted together, and held to gauge by cross-bars, the dimensions and distance of which, as well as of the angle-bars themselves, being varied in order to ascertain the maximum limit of saving material which may be approached without jeopardising the efficiency of the construction.

In the system shown in Fig. 2, the longitudinal rectangular angle-bearers measure 6 in. $\times$ 6 in. $\times$ $\frac{1}{2}$ in., and are placed half an inch apart, to allow the web of the head rail to slip in. The gauge, or cross-bars of T iron 4 in. $\times$ 3 in. $\times$ $\frac{3}{8}$ in. are placed five feet apart, and are riveted below to both the horizontal arms of the angle-bars.

In sytem No. 3 (Fig. 3) the rail-bearers are formed by angle-bars of 93°, the dimensions of which are reduced to $5\frac{1}{4}$ in. $\times$ $5\frac{1}{4}$ in. $\times$ $\frac{1}{2}$ in., the head-rail, head-bolts, and their distance apart being the same as in system No. 2; but the cross-bars, here placed only three feet apart, were made of flat bar 3 in. $\times$ $\frac{1}{2}$ in., ending in a T section, which is riveted through the two arms of the rail-bearers. In order to prevent the squeezing together of the latter, a half-inch fillet-plate is inserted between them. The fishing of joints is effected as in system No. 2, and the horizontal-bearing surface is 274 square inches per running foot of railway.

On the wear of the railway, the engineer, Mr. Scheffler, reports as follows: "The two systems lie side by side in a straight line, half the distance being on well-drained large gravel, the other half in fine gravel mixed with clay, very impermeable to the percolation of water. Both lengths have been worked for more than two years, and are in excellent preservation, continuing to bear a heavy express, passenger, goods, and mineral traffic. The state of the rails has been uninterruptedly satisfactory, and they have not required the same labor of keeping up which was necessary for the other portion of the railway. This contrast was especially remarkable in winter during a prolonged low temperature. After the thaw in the spring of 1865, only in the system No. 3, in those portions of the line where the ballast is unusually bad and clayey, a few instances of sinking occurred, but not to the same extent as on the line with cross wooden sleepers; however, on the larger portion of system No. 3, and on the whole of system No. 2, no packing or adjusting of any kind has been necessary. This favorable result is, perhaps, to be ascribed to the great height of the rail-bearers, which permit the bearing surface to lie deep in the ballast, and reduce the influence of frost on the base of the rail. The packing and lifting, when required, are an easy operation, and these constructions have shown no instability—a gratifying fact, since eminent engineering authorities, looking at the flat base of the rail-bearers, predicted a shifting sideways of the whole line. After two years' heavy traffic no displacement has been perceptible; all the component parts of the iron permanent way are in their original good condition; not a single rivet has worn loose, but the nuts of the head-bolts require now and then to be tightened with a spanner, as in those

of the fish-plates of the ordinary construction. The iron, including the portion submerged in the ballast, has been oxidized to a trifling extent, and hitherto experience has not justified the preference of one system over the other. The motion on both systems is a little harder, but, at the same time, much more steady and smooth, than on the most carefully constructed permanent way with wooden sleepers. Hitherto it has been impossible to note any difference in the motion of the carriages during the various influences of extreme heat or cold, it is the same in winter as in summer. In the manufacture of the rail-bearers for sytems Nos. 2 and 3, the Hoerder works found a difficulty in rolling the top of the vertical arm to a sufficiently clear edge, and this inconvenience necessitated their being planed. In order to obviate this expensive operation, the Hoerder works proposed to roll the top of the vertical arm with a bulb or rib, which allows a true edge to be produced without any further mechanical finishing. The Brunswick Railway thereupon resolved to adopt this bulb angle in their last system, No. 4 (Fig. 4), embodying the weight of the smaller section No. 3, which in practice had proved sufficiently strong, at the same time giving a conical form to the head bolt, in order, when tightening the nut, to press the head rail down on the rail-bearers. This head is made of cast steel. While keeping to the weight of the former section they increased the height of the vertical arm to $6\frac{1}{2}$ inches, the horizontal arm to $5\frac{1}{2}$ inches, the thickness of both being $\frac{3}{8}$ths of an inch full. Another deviation from systems No. 2 and 3 is the form of the cross-bars, which are of channel or C iron, 4 in. $\times$ $1\frac{3}{4}$ in. $\times$ $\frac{3}{8}$ths of an inch, placed five feet apart, as in system No. 2, and are fastened with bolts and nuts through the two vertical rail-bearers. The horizontal supporting surface of this system is 306 square inches per running foot of railway. It does not appear advisable to place the cross-bars at a greater distance from each other, since they not only serve to keep the line to gauge, but also contribute in holding each pair of rail-bearers together to prevent their buckling; and, at all events, the greater rigidity of the system compensates for the trifling, if perhaps superfluous, outlay. Experience will teach us the maximum distance of the cross-bars, and also whether a large number and their submersion in the ballast offer (as we have hitherto found) a sufficient resistance to the supposed tendency of the railway to move sideways, or whether it is advisable, for additional security, to adopt keel-fishes. The cost of the iron permanent way, exclusive of ballast and laying down, has been 36*s*. per yard, or, with laying down, £3200 per mile, as against 25*s*. per yard, or £2250 per mile for the ordinary construction with wooden sleepers. The weight of the three systems is—No. 2, per yard, 354 lbs.; No. 3, 295; No. 4, 300. The Hoerder works supplied the materials for systems Nos. 2 and 3 at £13 5*s*. per ton, delivered at Brunswick; but for system No. 4 stipulated an advance of 5*s*. per ton, on account of the wider dimensions of the angle-bars, which necessitated the use of better iron. The building up and laying of the permanent way, after the laborers got used to the work, pro-

Fig. 1.

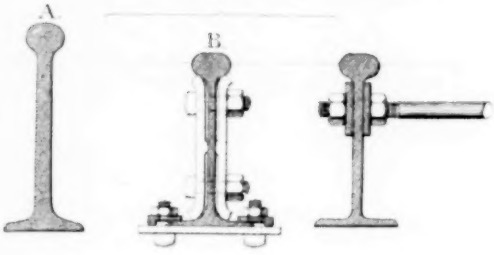


Fig. 3.

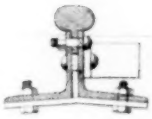


Fig. 2.

Fig. 4.

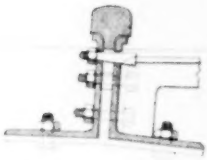


Fig. 5.

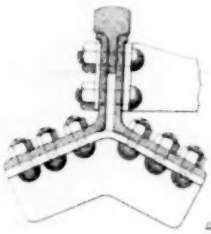


Fig. 6.

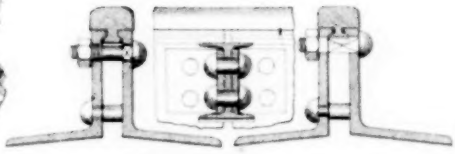
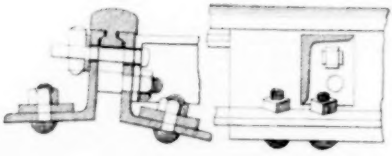


Fig. 7.



gressed rapidly; the cost of laying down was 10*d.* per yard as against 7*d.* per yard for the old system. The ballast under the iron way is of the same depth as that under the wooden sleepers, viz., 12 inches, and practice has shown this to be sufficient.

"The experience of two years has not yet furnished conclusive data exactly to fix the cost of keeping up the line, but we have found—

"1. That packing has been much less needed than with the ordinary cross-sleepers, and the expenses under this head are merely nominal.

"2. The rails have not required any repairs; neither head-rail nor rail-bearers have been renewed or altered; and it is remarkable that the rail-ends have suffered much less (owing to their uniform support) than on the cross-sleepers.

"The principle of longitudinal construction is, in theory, the most correct, and is borne out by practice. The even continuous bearing is of immense importance to the permanent way, as well as to the rolling stock, and gives a much easier motion to engines and carriages.

"The uniform rigidity of this rail system, and the perfect support of the head-rails, show a marked improvement in the wear of the heads. The use of rivets—in places where frequent renewals are not likely to occur, as in parts covered by the ballast, and therefore not much shaken—is not objectionable. The number of component parts is not large, their connection is easily established, and practice has proved the construction to be strong. The rigidity of the iron permanent way, both vertically and horizontally, is much greater than that of the cross-sleepers. This is proved, not only by the analysis of form and dimensions of the section, but also by the steady motion of the rolling stock, and this advantage is conspicuous in express and heavy mineral trains."

Thus far Mr. Scheffler. After the favorable experience obtained on the Brunswick line, the Hanoverian, Cologne-Minden, the Saxon and Wurtemburg State railways, have resolved to lay down experimental lengths of iron permanent way, constructed on analagous principles.

The Hanoverian system, illustrated by Fig. 5, was made by the Hoerder works, according to the specifications of the engineer of the line, but it does not appear to offer any advantage in theory, while its cost is much higher than that of the Brunswick system. The Hanoverian permanent way has the same cast-steel head as system No. 4; but the rail-bearers, $\frac{1}{2}$ inch thick, are formed of angle-bars of 115°, $5\frac{1}{2}$ inches high, and $6\frac{1}{2}$ inches base, giving a horizontal bearing of 12 inches wide, equal to 288 square inches per running foot of railway.

The rail-bearers are riveted together, with a fillet plate, as in system No. 3. The head-bolts, conical, as in system No. 4, placed 18 inches apart, have a collar under the nut, which, pressing the rib of the angle, counteracts the supposed tendency of the head-rail to incline outwards.

The bars, 3 feet apart, of 3 inches $\times \frac{3}{4}$ inch flat bar, are, as in system No. 3, riveted with T angles to the angle-bearers. The keel fish-

plates are formed of T iron, 5 inches × 2½ inches × ½ inch. About five miles of this iron permanent way were laid down in 1866, which give a very satisfactory result; they will, however, only be thoroughly reported on after next spring.

A variation of the iron permanent way of systems Nos. 3 and 4, is now being constructed at Hoerde for some German railways, on a plan patented in this country by the author, and the advantage of which was developed during the manufacture of the material for the Brunswick and Hanoverian way. (Models, full and half size, were on the table.) When the metal used for the head-rail was changed from the use of the iron to the use of cast-steel, it was no longer practicable to punch the bolt holes in the web, and every hole had, at considerable expense, to be bored and slotted out.

Besides, under all circumstances, particular care was required in correctly adjusting the holes in the web with those of the rail-bearers. These combined considerations made it desirable to devise a system establishing a direct and strong connection of the head-rail and rail-bearers, without the head bolts passing through both, and led to the combination illustrated by Figs. 6 and 7.

The bulb or rib of the vertical arm instead of being placed outside, as in the Brunswick permanent way, No. 4, is here turned inwards, and is rolled into a dwarfed T section, thus forming a groove into which the ribs or bulbs of the rail-bearer gripe; and the whole system is tightened and firmly held together by the screw bolts, or wedge keys, passing through the rail-bearers under the head without touching the web at all. The head bolts are placed 20 inches apart; and in order to prevent their pressing the angle-bars closer together than necessary, a stop rivet is placed under each of them near the throat of the angle, which thus keeps each pair of rail-bearers at the proper distance from each other.

In Fig. 7 a plan is suggested to effect economy of material by slightly reducing the height of the rail, and replacing expensive screw bolts with cheaper keys and wedges, all of which can be simply rolled as a bar and cut off to the requisite size.

The cross-bars of these systems can, of course, be made of any section of iron. Those now making are partly of double T iron, partly of angle iron, bolted to the inner arm of the construction. By these means the outer arm of the rail-bearer can at all times be removed for the purpose of shifting, reversing, or renewing the head rail, without disturbing the gauge of the railway. The cross bars are most conveniently fitted near the end of the rail-bearers, where they contribute to stiffen the fish-joint, and at the same time serve admirably as supports of the points, which move easily over the flat surface of the cross bar.

In order to prevent the sliding backwards and forwards of the head rail by the friction of the wheel, a square stop bolt is applied to the head, passing through a notch in the web at each end of the rail. A few holes are punched here and there in the horizontal arm of the rail-bearer to assist in draining the ballast.

It is scarcely necessary to urge anything in favor of the principle of longitudinal permanent way generally. In some countries the first cost may appear greater; but the ever-increasing expense of keeping up wooden sleepers, especially in hot climates; the interruption of and danger to traffic during repairs; and, on the other hand, the advantages offered by the iron way of decreased wear of rolling stock, as well as increased safety and comfort in traveling, are considerations of such importance as to render the abandonment of the present cross-sleeper construction merely a matter of time.

In the systems just described the life of the iron parts is practically unlimited. The only portion subject to gradual wear is the steel head, weighing about 34 lbs. to the yard; and this economical application of the more expensive material justifies the engineer in using crucible cast steel of a high class, instead of the cheaper but less durable Bessemer steel, which, for good financial reasons, is the only steel which railways have hitherto allowed themselves to use.

The weight of the new system, as per dimensions shown in Fig. 6, is 223 tons per mile; the cost, inclusive of laying at 9*d.* per yard, about £3100.

The weight of system No. 7 is 193 tons, and the cost about £2700 per mile of single railway. But these prices are based upon the use of high-class Prussian iron, at £12 to £14 per ton, and bolts from £24 to £30 per ton; with the use of English iron the cost per mile should not exceed £2200 per mile.

I would finally urge, in favor of the iron permanent way, the consideration that wood is getting scarcer and dearer every year, and may well be saved from decaying in the ballast, in order to fulfil the nobler mission of meeting the numerous wants of our domestic and social habits and dwellings. And if railways in England and its colonies were generally to adopt the iron permanent way, an immense impulse would again be given to an industry now unfortunately languishing, but the prosperity of which forms the back-bone of the wealth and power of this country.

Weight and Cost of System No. 6 per Mile, calculated on the price of Prussian Iron.

(PER LENGTH OF 20 FEET.)

				£.	*s.*	*d.*
2 head rails	460 lbs.,	at 16*s.* 6*d.*	cwt.	3	7	9
4 rail bearers	1180 "	12*s.* 0*d.*	"	6	5	7
3 cross bars	170 "	13*s.* 6*d.*	"	1	0	9
4 fish plates	26 "	12*s.* 0*d.*	"	0	3	0
62 bolts and nuts	48 "	30*s.* 0*d.*	"	0	12	9
22 stop bolts	8 "	24*s.* 0*d.*	"	0	1	9
	1892 lbs.			£11	11	7
= per mile, 223 tons				£3056	18	0
Laying down, at 9*d.* per yard				66	0	0
Total				£3122	18	0

Weight and Cost of System No. 7 per Mile, calculated on the price of Prussian Iron.

(PER LENGTH OF 20 FEET.)

2 head rails	460 lbs.,	at	16*s.* 6*d.*	cwt.	3	7	9
4 rail bearers	1050	"	12*s.* 0*d.*	"	5	12	6
4 cross bars	44	"	12*s.* 0*d.*	"	0	4	8
4 fish plates	26	"	12*s.* 0*d.*	"	0	3	0
26 wedges and cotters	37	"	18*s.* 0*d.*	"	0	5	11
18 stop bolts	7	"	24*s.* 0*d.*	"	0	1	6
16 bolts and nuts	16	"	30*s.* 0*d.*	"	0	4	0
	1640				£9	19	4

= per mile, 193 tons	£2631	4	0
Laying down, at 8*d.* per yard	57	0	0
Total	£2688	4	0

THE USE OF ANTHRACITE COAL AS A FUEL.

By P. W. SHEAFER, Engineer of Mines, Pottsville, Pa.

THE accompanying anthracite coal monument [Plate V.] represents the wonderful and recent appreciation of this kind of fuel.

That portion of Pennsylvania purchased from the Indians at a treaty in Philadelphia on the 22d August, 1749, for £500, embraced all of the middle and southern coal fields included in all that district north of the Blue Mountains, and extending from the Lehigh to the Susquehanna rivers. The northern, or Wyoming and Lackawanna coal districts, were included in the Fort Stanwix purchase of November 5, 1768, which great area, reaching from the south-western to the north-eastern boundaries of Pennsylvania, cost $10,000.

The following data show how anthracite coal struggled into recognition as a fuel:

In 1768 anthracite coal was first used in Wyoming Valley by Obadiah Gore, (blacksmith.)

In 1775 and '76—several boat loads of anthracite coal were sent from Wyoming down the Susquehanna, and thence hauled to Carlisle barracks, to manufacture arms.

In 1790—coal first known in Schuylkill county.

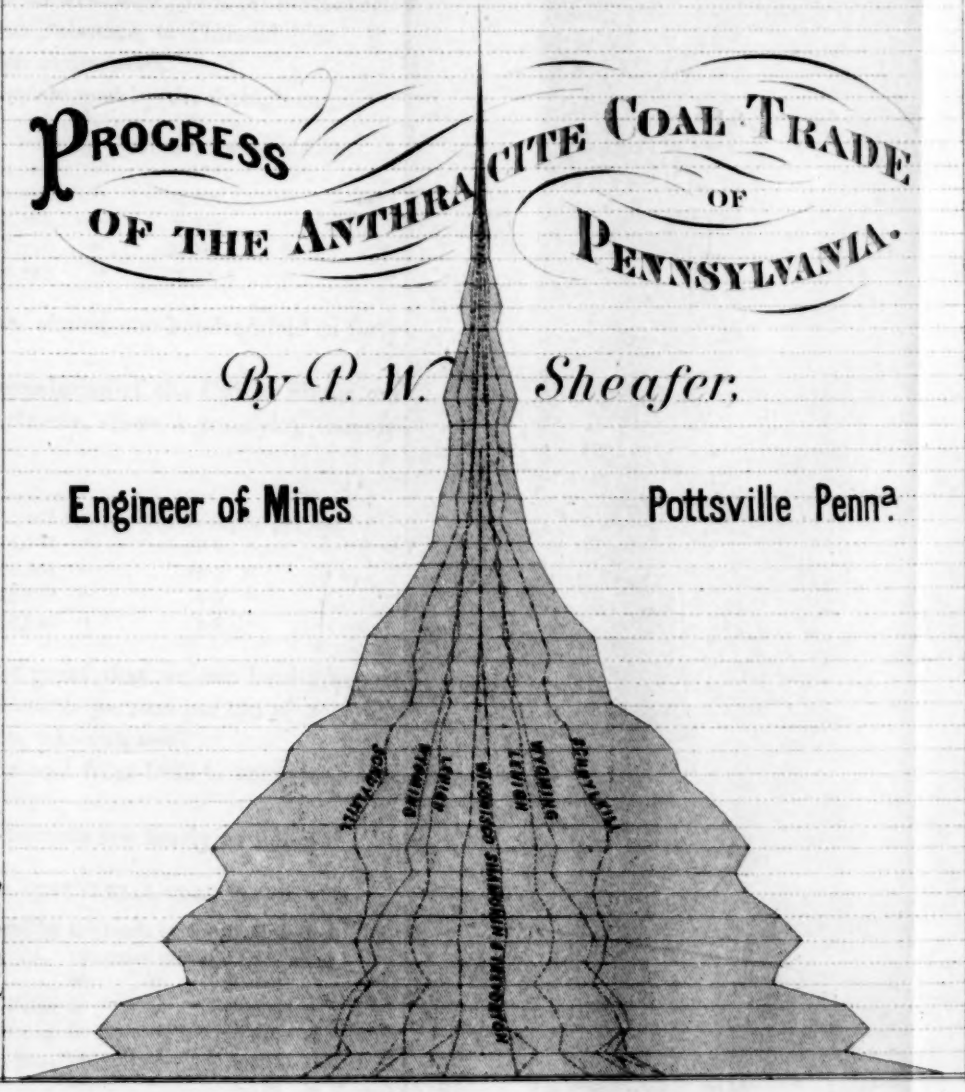
In 1794—blacksmiths used it in Schuylkill county.

In 1808—used in grates by Judge Fell, of Wilkesbarre.

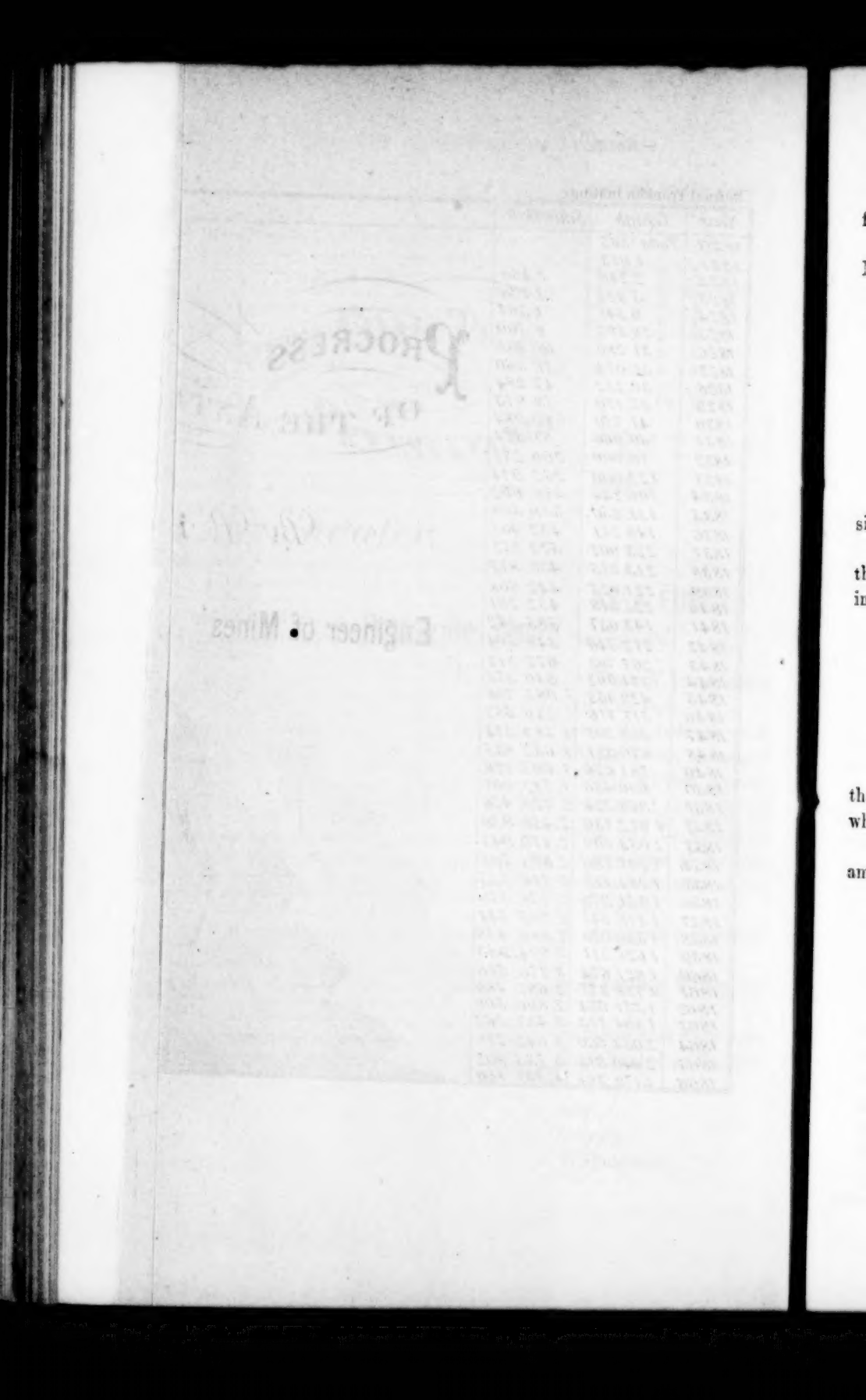
Progress of the Anthracite Coal Trade of Pennsylvania.

By P. W. Sheafer,

Engineer of Mines Pottsville Penna



Year	Lehigh	Schuylkill	Wyoming:	Shamokin Mahanoy & Trevorton	Total Tons:
1820	Tons 365		Tons	Tons	Tons 365
1821	1,073				1,073
1822	2,240	1,480			3,720
1823	5,823	1,128			6,951
1824	9,541	4,567			14,108
1825	28,393	6,500			34,893
1826	31,280	16,767			48,047
1827	32,074	31,360			63,434
1828	30,232	47,284			77,516
1829	25,110	79,973	7,000		112,083
1830	41,750	89,984	43,000		174,734
1831	40,966	81,854	54,000		176,820
1832	70,000	209,271	84,600		363,871
1833	123,000	252,971	111,777		487,748
1834	106,244	226,692	43,700		376,636
1835	131,250	339,508	90,000		560,758
1836	148,211	432,405	103,861		684,117
1837	223,902	523,152	115,387		879,444
1838	213,615	433,875	78,207		738,697
1839	221,025	442,608	122,300	11,930	818,402
1840	225,318	452,291	148,470	15,005	864,384
1841	143,037	585,542	192,270	21,463	959,973
1842	272,546	541,504	252,599	10,000	1,108,418
1843	267,793	677,312	285,605	10,000	1,263,598
1844	371,002	840,378	365,911	13,087	1,630,850
1845	429,453	1,083,796	451,836	10,000	2,013,013
1846	517,116	1,236,582	518,389	12,572	2,344,005
1847	633,507	1,583,374	583,067	14,904	2,882,309
1848	670,321	1,652,835	685,196	19,356	3,089,238
1849	781,656	1,605,126	732,910	45,075	3,242,966
1850	690,456	1,712,007	827,823	57,684	3,358,899
1851	964,224	2,229,426	1,156,167	99,099	4,403,730
1852	1,072,136	2,450,950	1,284,500	119,342	4,993,471
1853	1,054,309	2,470,943	1,475,732	113,007	5,195,151
1854	1,207,186	2,895,208	1603,478	234,000	6,002,334
1855	1,284,113	3,318,555	1,771,511	240,338	6,604,318
1856	1,351,970	3,258,356	1,972,581	313,444	6,927,580
1857	1,318,541	2,985,541	1,952,603	388,255	6,663,828
1858	1,380,030	2,886,449	2,186,094	370,424	6,759,369
1859	1,628,311	3,004,953	2,731,236	443,755	7,780,518
1860	1,821,674	3,270,516	2,941,817	479,116	8,412,946
1861	1,738,377	2,697,489	3,055,140	463,308	7,843,211
1862	1,351,054	2,890,598	3145,770	481,990	7,739,899
1863	1,894,713	3,433,265	3,759,610	478,418	9,631,101
1864	2,054,669	3,642,218	3,960,836	519,752	10,184,320
1865	2,040,913	3,735,802	3,254,519	621,157	9,652,391
1866	2,179,364	4,957,180	4736,616	830,722	12,703,882



In 1812—Col. Geo. Shoemaker hauled nine wagon loads of coal from Pottsville to Philadelphia, and gave away the coal.

In 1814—Charles Miner sent an ark load (24 tons) of coal from Mauch Chunk *via* the Lehigh and Delaware, to Philadelphia.

In 1815—Schuylkill navigation commenced.

In 1820—365 tons of coal were shipped by the Lehigh canal.

The coal product in	1820	was	365	tons, equal to	1	ton per diem.
"	" 1830		174,734	"	479	"
"	" 1840		864,384	"	2,368	"
"	" 1850		3,358,899	"	9,203	"
"	" 1860		8,412,946	"	23,049	"
"	" 1866		12,703,882	"	34,805	"

The increase per diem has been almost one hundred-fold in forty-six years.

The comparison between the population of the United States and the anthracite product of Pennsylvania, shows a gratifying increase in regard to both.

	Population.	Coal product.			
1820.....	9,683,131	365 tons, or	25,529	capita per	ton.
1830.....	12,866,020	174,734 "	73·6	"	"
1840.....	17,069,453	804,384 "	19·5	"	"
1850.....	23,191,876	3,358,899 "	6·5	"	"
1860.....	31,641,977	8,412,946 "	3·8	"	"

The increase of population is so great that we can hardly expect the product of coal in 1870, to be three persons per ton of coal, and when it will be one person per ton, who can tell?

The gross product of anthracite coal from 1820 to 1866, inclusive, amounts to 149,876,119 tons.

The areas of the several coal districts are nearly as follows:

THE FIRST SOUTHERN OR SCHUYLKILL COAL FIELD.

1. East of Tamaqua mostly covered by the lands of the Lehigh Coal Navigation Company.....	16	square miles,	10,240 acres.
2. Tamaqua to Pottsville.....	36	"	23,040 "
3. Pottsville west, to Forks of Basin	55	"	35,200 "
4. North Fork, or Lykens Val. Prong	16	"	10,240 "
5. South Fork, or Dauphin Prong....	15	"	9,600 "
6. North Mine Hill Range.....	8	"	5,120 "
Total area of Southern coal field	146	"	93,440 "

THE SECOND OR MIDDLE COAL FIELD.

1. Shamokin District	50	square miles,	32,000 acres.
2. Mahanoy "	41	"	26,240 "
3. Beaver Meadow, Hazleton, Big and Little Black Creek	35	"	22,400 "
Total area of second coal field	126	"	80,640 "
The 3d Northern or Wyoming and Lackawanna coal field	198	"	126,720 "
Total area of the anthracite coal fields	470	"	300,800 "

The average yield per acre thus shown in forty-six years, amounts to nearly 500 tons. The inquiry naturally follows as to how much remains. In former calculations, we made the coal thickness of the

Southern coal field to be	25 yards.
Middle "	15 "
Northern "	15 "

These sums, multiplied by the number of acres in each field, give the following results:

In the first coal field	11,308,824,000	cubic yards or tons.	
" second "	5,854,964,000	"	"
" third "	9,179,872,000	"	"
Total	26,343,660,000	"	"
Deduct half for waste in mining and breaking	13,171,830,000	"	"
Balance	13,171,830,000	"	"
Deduct amount mined in forty-six years	149,876,119	"	"
Balance on hand	13,021,953,881	"	"

equal to 43,291 tons per acre.

These figures give an amount of coal "in the hold," equal to a demand of 20,000,000 per annum for 651½ years in the future.

The correctness of these data may be brought into question, but not fairly disputed.

The coal area is well defined and correctly shown on our maps; the coal thickness for each coal field is not over-estimated, and the deduction of one-half from the gross amount, should cover all waste incident to our extravagant and careless mode of mining, and the yet more improvident waste in the preparation of coal for market. I have estimated 20,000,000 tons per annum for a future demand; this amount is assumed by some as the maximum product of our mines.

I can hardly believe it to be our limit. With so grand a supply at our command, with all the modern and improved appliances for extracting coal from the mines, with more numerous shafts, slopes, tunnels and drifts, and, more than all, the indomitable energy and skill of our people, we can scarcely imagine a demand to which we are not equal.

COFFER-DAM AT TURNER'S FALLS,

On the Connecticut River.

By JAMES B. FRANCIS, Civil Engineer.

TURNER'S FALLS are situated in the towns of Gill and Montague, Massachusetts, about a hundred miles from the mouth of the river. The fall, which with the rapids below, is about sixty feet, is produced by a ridge of the new red sandstone, well-known to geologists as affording fossil foot-prints in great numbers and variety.

In the year 1792, the Proprietors of the locks and canals on Connecticut River were incorporated by the State of Massachusetts, for the purpose of making certain parts of the river navigable for boats and rafts. Within a few years after the passage of this Act, a canal about three miles in length, was made in Montague, around Turner's Falls; a considerable portion of the capital required having been furnished by Dutch capitalists. This investment gave profitable returns for many years, but the exhaustion of the timber in the upper parts of the valley, and the construction of railroads, led to its abandonment for navigation purposes. In 1866, the stock having passed into new hands, the name of the corporation was changed to the Turner's Falls Company, and they were authorized to increase their capital to $1,000,000; the object of the new company being to develop the vast water-power furnished by the Connecticut River at this point, and thereby build up a large manufacturing city.

A dam had been maintained for many years by the old Navigation Company, but since the disuse of the canal, one-half of it had been carried away, and the remainder had become greatly dilapidated. The first work undertaken by the Turner's Falls Company, was to construct a new dam across the river, about twenty-three feet in height and nine hundred feet in length, of timber and stone.

At the site of the dam the river is divided into two branches by a rocky island about forty feet high. The part of the old dam still remaining, was between this island and the Gill shore, diverting the

entire flow, in ordinary stages of the river, to the channel on the Montague side of the island. Advantage was taken of this to construct the dam on the Gill side, before doing anything on the Montague side, the new dam being built a short distance below the old one. This part of the new dam was so constructed that the water could be turned through it, so as to enable the part on the Montague side to be built without making a coffer-dam high enough to turn the water over the top of the finished part of the dam on the Gill side. For this purpose, about two hundred feet in length was left about twelve feet below the level of the top of the finished part of the dam. To enable this opening to be built up when the dam on the Montague side was completed, large timbers were placed vertically from the toe of the dam, about eight feet apart, and supported by tie-rods, anchored to the rock. While the dam on the Montague side was being built, it was designed that the whole flow of the river should pass between these timbers and through the opening in the dam; and when the other part of the dam was completed, the flow through the opening should be stopped and the water turned over the top of the finished dam, by planking up the timbers put in for that purpose. During October, 1866, the coffer-dam on the Montague side was completed, and the entire flow of the river was diverted through the opening on the Gill side. On the 31st of that month, however, there was a freshet, which brought down trees and stumps, and broke away some rafts of timber intended for the new dam. These came against the vertical timbers, breaking them off, and the great volume of water rushing through the opening washed out the substructure of the dam, clean to the rock, for about one hundred and ten feet in width. On the subsidence of the freshet, work was resumed on the Montague side, the river flowing through the breach on the Gill side, and by the middle of December the dam on the Montague side was completed.

And now came the interesting question, what was to be done with the breach in the dam? If it was allowed to remain until another season, there was great reason to fear that the whole of the section on the Gill side of the island would be carried away when the ice broke up in the spring. On the other hand, to fill up the breach during the winter seemed to be scarcely practicable, the great difficulty being to divert the flow of water from the breach. This could only be done by turning it over the top of the finished part of the dam; but, in order to do this, the water must be raised twelve or fifteen feet, by means of a coffer-dam, above the breach, directly in the

current. This coffer-dam must be built and the breach filled up before the ice broke up in the spring, otherwise it was deemed certain that all that might be done would be carried away. The Connecticut river is subject to freshets at all seasons of the year. In the winter, a thaw of a few days will often break up the ice in some of the tributaries, carrying it into the main river, where it accumulates and subsequently freezes together, so that when a high freshet occurs in the main river, masses of ice, often exceeding ten feet in thickness, are carried down with the current. Such a freshet is looked for every year, in January or February, and and if one occurred before the breach could be filled, it would render useless all that might be done. Then there was the difficulty of doing any work, in the water, in a climate of such severity as that of Northern Massachusetts, to say nothing of the short days. However, the practical men who would have the work to do, were willing to attempt it, and felt confident that if they escaped a winter freshet, they could accomplish it. It was accordingly decided by the directors of the company to make the attempt.

The coffer-dam* was devised by Mr. George W. Potter, of Greenfield, Massachusetts, the agent of the company, and Mr. Alonzo P. Richardson, of Pishon's Ferry, Kennebec Co., Maine, the superintendent of the work. Plate VII. is a plan and section of the coffer-dam. C C is the finished dam on each side of the breach; D, the breach through which the entire volume of the river must continue to flow, until it could be turned over the finished parts of the dam. The flow of the river, while the work was in progress, is estimated as varying from about 5000 to 10,000 cubic feet per second, the depth of the water in the breach varying from 5 to 8 feet, and its velocity from 10 to 12 feet per second, excepting during one freshet, to be noticed hereafter, when it was much greater. E, E, E, are cribs, built of timbers, about a foot square, taken from the remains of an old dam. These cribs were framed on the shore and floated to their places, being held in the current by strong guys; when in the desired position, they were filled with stone, which gave them sufficient stability to retain their position without aid from the guys. These cribs rested on the rock, and after being placed and loaded, were built up

* The term *coffer-dam* strictly means a dam formed of a double row of piling, with the space filled with a water-tight puddle; latterly the term appears to be applied to a dam of any construction for the purpose of enabling any work to be done under water.

to a uniform height, F F, (see the section in Plate VII.) which was above the level of the water, which flowed through the spaces between the cribs, and through the interstices in the wood and stone work. A platform of timber was then laid on top of the cribs, covering also the spaces between them; on top of this platform was built a dam, G, sloping up stream 2·5 horizontal to 1 vertical, as represented in the section, the slope being planked, and the top of it being about 3·5 feet above the top of the finished part of the dam; making the whole height of the coffer-dam about twenty-five feet. The next thing was to stop the flow through the ten openings between the cribs; this was done by means of the plugs, H, H, H, which were framed to fit the spaces they were intended to close; planked tight on their up-stream ends, and floated to their respective positions by means of guys. Great quantities of stone, brush and gravel were then thrown in on the upper side of the cribs, which stopped nearly all the leakage and diverted the flow over the finished parts of the dam.

The first crib was placed December 31, 1866, and the last on the 16th of January following. The last plug was put in on the 1st of February. The remainder of February was occupied in tightening up with stone, brush and gravel. March 1st, the filling up of the breach in the main dam was commenced, and was completed on the 22d of that month. Fortunately, there was no freshet sufficient to break up the ice in the main river while the work was in progress. February 11th, the water was high, being about six feet on the crest of the finished part of the dam, and about 2·5 feet above the top of the coffer-dam, doing, however, no material injury, further than to cause a suspension of the work for a few days. About seventy men were employed, and notwithstanding the extreme severity of the weather during January, the temperature, much of the time, being below zero, there was no unusual sickness among the men, and no life was lost, or any serious accident occurred. Two of the piers were lost while floating them to their places, by the breaking of the guys.

Thus was happily completed a work remarkable for boldness and ingenuity of design, simplicity of means, and skill and courage in execution, under the most difficult and hazardous circumstances. The entire credit must be given to Messrs. Potter and Richardson, who designed it, and, with the assistance of a gang of hardy and resolute men, executed it; and to the Hon. Alvah Crocker, of Fitchburg, the President, and Wendell T. Davis, Esq., of Greenfield, the resident director of the company, who had the courage to proceed under such circumstances, and who brought out the full energies of their men by their confidence and encouragement.

COFFER DAM
at
TURNERS FALLS
Mass.
Scale 1 inch = 32 feet
1857

Section at A B.

A

B

C

D

E

G

H

Mechanics, Physics and Chemistry.

(Continued from page 193.)

LECTURES ON VENTILATION.

Delivered before the Franklin Institute, by L. W. LEEDS, Esq.

LECTURE II.

As I stated at our last lecture, much interest is being awakened, in this country and in Europe, by recent investigations showing the enormous numbers of untimely deaths that are caused throughout all classes of society by foul air.

It would have been a startling announcement, ten years ago, to have stated that impure air caused as many deaths, and as much sickness, as all other causes combined, and yet the most diligent and accurate investigations are rapidly approaching that conclusion.

Few really comprehend the immense pecuniary loss, saying nothing of the amount of suffering that we endure by this extra and easily preventible amount of sickness.

I propose, this evening, to enter upon the consideration of one of the most important parts of our subject—*the effect produced by* HEAT *upon the movements of air.*

I think it probable that many of us do not comprehend the actual reality of the air.

We are apt to say of a room that has no carpet or furniture in it, that it has nothing in it, while, if it is full of air, it has a great deal in it.

A room between twenty-seven and twenty-eight feet square contains one ton of air—a real ton, just as heavy as a ton of coal. Now, there is not only twenty-seven feet, but more than twenty-seven miles of air piled on top of us. The pressure of the atmosphere at the level of the ocean is about fifteen pounds to the square inch. An ordinary sized man sustains a pressure of about fifteen tons, and were it not that this pressure is equal in all directions, we would be crushed thereby.

We must accustom our minds, therefore, to consider air a real substance, and that it is as totally unable to move itself, or of being moved, without *power*, as water or coal. It requires just as much

power to move a ton of *air* from the cellar to the second story, as it does a ton of coal.

Heat is the great moving power of air. Those whose attention has not been especially directed to the subject of the amount of power exerted by the sun's rays upon the earth, have little conception of its magnitude.

The power of all the horses in the world, added to the power of all the locomotives, and of all the immense steam engines in all the world, express but a small fraction of the power exerted by the sun's rays upon the earth. It is estimated to be sufficient to boil five cubic miles of ice-cold water every minute.

His rays are the chosen power of the Creator for moving all matter upon the globe. It is his rays that lie buried in the vast coal fields beneath the earth. His rays cause every spear of grass to grow, rears the mighty oak, forms the rose, bursts its beautiful buds, and sends its perfume through the air.

No bird warbles its sweet music in the air, no insect breathes, save by his power, and all animals love to bask in the genial glow of his light and heat. He rolls the scorching air of the tropics to frozen lands, wafts the ships across the seas. He forces the heated waters of the equator to the poles, tempering all the earth. He lifts the water from the sea to sprinkle all the land and cap the distant mountains with eternal snow.

Now, let us examine a little more minutely how this influence is exerted upon the *air*, which is the subject we are especially interested in at present.

Does it commence at the top, and heat it, layer by layer, until it reaches the bottom? Not at all; but it passes through the whole forty-five miles of air, heating it very little, if any, and falls upon the solid substances at the earth's surface, heating them, which, in turn, heat the air by its individual particles coming in immediate contact with those solid hotter substances.

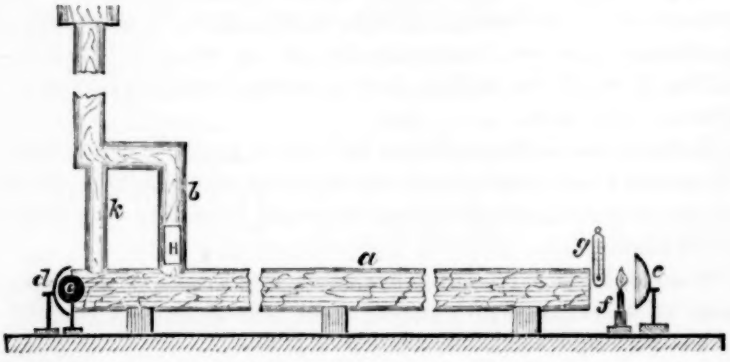
We will endeavor to illustrate this in a crude way.

Here we have a tin tube, A, fifteen feet long and ten inches in diameter, open at both ends; two feet from one end we introduce this ascending pipe, B, the upper end of which is merely inserted in a small flue, extending to the top of the building. The height of this flue is sufficient to make a current of air pass through this tube, as you will see by holding this smoking taper at the far end. We will now place a large heated ball, C, at this end, and outside of that we

will place this reflector, D, pressing it quite close to the end of the tube, so that no air can enter here.

The rays of heat from this ball, or from any other warm body, are thrown like rays of light, in every direction equally; there would,

Fig. 7.



therefore, be some of the rays thrown through this tube to the other end without any reflector, but the proportion that would reach the other end would, of course, be small.

We therefore collect those going the other way, and change their course, and then send them straight through the tube to the far end.

We will place another reflector, E, at the far end, to receive and concentrate those rays, in the focus of which we will place a candle, F, with a little phosphorus on it, to show you that the rays of heat are passing through.

There you see the candle is lighted, thus proving that there is a strong current of radiant heat coming from the hot ball, through the tube to this end. And you see by this smoke that there is a current of air passing the other way.

Now, we want to know how much that air is heated in passing the whole length of this tube against that shower of radiant heat, or whether air absorbs radiant heat at all; but, before going to the other end, where the hot ball is, we will take two thermometers that have been lying here, side by side, and both indicate a temperature of 69°. One of them, C, we will hang at this end, about opposite to the centre of our tube, which, I think, will give us a fair average of the entering air, first removing, however, the candle that has been lighted, and the reflector.

We will hang the other thermometer in the ascending tube, at the

end near the heated ball. We have had two glasses, H, inserted here, so we might observe what was going on within by the smoke from this taper. You see there is a strong current of air passing up the tube, all of which must come from the far end, flowing against the strong current of radiant heat going in the opposite direction. Now, leaving this thermometer to rise or fall according to the temperature of the air flowing through, we will go to the other end and examine another very interesting part of this experiment: it is the manner in which the radiant heat is received and appropriated by different substances.

Radiant heat is thrown from a hot body in every direction equally, but no two kinds of substances receive those rays of heat in the same manner, nor do they make the same use of them after they have received them.

Every substance receiving heat, however, must give a strict account of it. It must give out an equal amount of heat, or, what is taken as an equivalent, some action or power.

I have a sheet of ordinary tin, and as I hold this polished side behind this light, you see it throws a belt of light across the room, and as I put it in front of the end of our tube, and by turning it so the rays of heat will be reflected in your faces, I think some of you will be able to feel the reflected heat. The rays of heat are turned from their course, and thrown in a belt across the room, similar to the rays of light.

But you cannot give away and keep the same thing. This bright polished surface appropriates but a very small portion of the radiant heat. A thermometer hanging for some minutes against the back has scarcely risen one degree; but we have given the other side a coating of lamp black, with a little varnish, and by turning that side towards the pipe, the result will be quite different. By this coat of black varnish the whole character of the sheet of tin is changed. The black, however, has but little to do with it; if it was white, or red, or blue, the formation of the surface being similar in every respect, the result would be the same almost precisely.

Instead of acting merely as a guide-post, to *change* the *direction only* of the rays of heat, as before, it now becomes a receiving depot, absorbing nearly all the heat that comes to it. It must soon become filled, however. The thermometer hanging at the back has risen six degrees already, and is going up rapidly; it must soon begin to distribute its extra stores. But mark the different manner of distri-

buting the heat. Instead of *reflecting* the whole all in one direction, as when received on the other side, it now *radiates* them equally in every direction.

Some solid substances allow the rays, both of heat and light, to pass directly through them without either reflecting or absorbing them. Other substances allow the rays of light to pass through them, but absorb much of the radiant heat, like clear glass.

Rock salt is one of the best non-absobents of radiant heat, allowing nearly the whole of the rays of heat to pass through unobstructed.

We will now return to our experiment at the other end of the tube. I find there is something wrong here—the mercury in the thermometer has risen several degrees. I knew this was rather a crude arrangement for illustrating this very beautiful and interesting part of our subject, but I hoped it would assist me a little in conveying to you the idea I desired to impress upon your minds. I find, however, it is scarcely delicate enough to illustrate perfectly what I wanted to show.

But this increased temperature is not owing to the effect of radiant heat on the air coming from the far end, but I find by the heat at the top of the pipe, between the heated ball and this ascending pipe, I, and by the current of heated air on the side next the ball, that there is a current of *circulating air* that *has been heated* by coming in immediate *contact* with the hot ball.

I designed this smaller tube, K, to carry off the air thus heated, but it appears to be too small.

We ought to have had a piece of rock-salt to have closed the end of this tube, so that the radiant heat would have passed through without allowing any *circulation* of *heated air*, but I was unable to find such a piece. But Professor Tyndall, in his lectures before the Royal Institute of Great Britain, gives the results of a large number of very accurate and beautiful experiments tried for the purpose of determining whether the forty-five miles of atmosphere surrounding the earth absorbed *any* of the sun's rays, and if so, how much?

These experiments prove, in the most conclusive manner, that dry pure air is almost a perfect non-absorbent of radiant heat. Thus, were the air entirely dry and pure, the whole forty-five miles through which the sun's rays have to pass, would absorb a very small fraction thereof, so that in the length of our tube it would be but an exceedingly small fraction of one degree, that is, for pure dry air.

But is the air of this room pure and dry? Very far from it.

Professor Tyndall found that the moisture alone in the air of an ordinary room, absorbed from fifty to seventy times as much of the radiant heat as the air does. Air and the elementary gases—oxygen, hydrogen and nitrogen—have no power of absorbing radiant heat, but the compound gases have a very different effect; for instance, olifiant gas absorbs 7950 times as much as air; ammonia, 7260; sulphurous acid, 8800 times. Perfumes, also, have a wonderful power of absorbing radiant heat.

The moisture in the air, however, is of the greatest practical importance in various ways. It is the great governor or regulator or conservator of heat; it absorbs it and carries it from point to point and into places where the direct rays of the sun could not get; it is like a soft invisible blanket constantly wrapped around us, which protects us from too sudden heating or too sudden cooling.

Professor Tyndall, speaking of the moisture in the air, says: "Regarding the earth as a source of heat, no doubt at least ten per cent. of its heat is intercepted within ten feet of its surface." He also says: "The removal for a single summer's night of the aqueous vapor from the atmosphere which covers England, would be attended by the destruction of every plant which a freezing temperature could kill.

"In Sahara, where the soil is fire and the wind is flame, the refrigeration is painful to bear."

And in many of our furnace-heated houses, we have an atmosphere very similar in point of dryness to that of Sahara, but more impure.

The foregoing remarks in regard to the impossibility of heating air, apply especially to radiant heat. Air does become heated, but in a different manner; it is heated by each individual particle or atom coming in immediate contact with some hotter substance. See what a wonderful provision for creating a constant circulation of the air. The sun's rays pass through it without heating it, but heat the surface of the earth at the very bottom of the ocean of air; these in their turn, heat the air by each individual atom coming in immediate contact with these hotter substances, expanding them so that they must rise, thus enabling the colder and heavier particles to rush in and take their places. With this great universal moving cause, in connection with the innumerable minor causes resulting from the very different absorbing, radiating and reflecting powers of various substances, it becomes almost impossible for the air to be entirely and absolutely at rest, even in the most minute crack or cranny, or bottle corked air-tight.

Now, to apply these principles to every-day life, to the heating and ventilation of our houses, taking the *open fire* first, we find that acts like the sun, heating exclusively by direct radiation. The rays of heat fall upon the sides of the room, the floor and ceiling, and the solid substances in the room which thus become partially heated, and in their turn become *secondary radiators*. This radiant heat from the fire does not heat the air in the room at all, but the air becomes partially warmed by coming in immediate contact with the sides of the room, the furniture, &c.

One great reason, therefore, why an open fire is so much more healthy than any other means of artificial heating, is because it more nearly imitates the action of the sun.

The rays of heat fall upon our bodies, heating them, while it leaves the air cool, concentrated and invigorating for breathing. The bright glow of an open fire has a very cheering and animating effect. It produces a very agreeable and healthy excitement.

It is not improbable that future careful investigations may prove that there is an important change takes place in the electric or ozonic condition of air as it passes over, or in contact with, hot iron, which does not occur to the air of a room heated by the open fire.

The air in a room heated by an open fire can scarcely become stagnant, because that fire must necessarily be constantly drawing a considerable amount of air from the room to support combustion, the place of which will be supplied by other air, and here is where one of the greatest inconveniences arises in the use of the open fire; if the air entering to supply this exhaustion comes in at a crack of the door or window, on the opposite side of the room, and that air is cold, say 10° or 15° above zero, it flows across the floor to the fire, chilling the feet and back of those sitting in its track. It is quite possible to roast a goose or round of beef in front of a fire, while the air flowing by it into the fire is freezing cold. This should be remedied by having the air flowing in partially warmed before it enters, say to a temperature of 40° to 50°, either by having the halls overflowed by partially warmed air, and opening a door into it, or by admitting the air to enter around the back of the fire-place, as Dr. Franklin arranged it.

Thus, while an open fire is the healthiest known means of heating a small room, and should be in the family sitting-room of every house, and in offices and other places where the occupants are at liberty to move closer or further from the fire at pleasure, yet it is

entirely unsuitable for a large building, or for rooms where many persons are assembled, and have fixed seats, similar to a school, lecture-room, factory, &c.

A stove in a room heats both by direct radiation and by heating the air that comes in immediate contact with it.

But our latest styles of elegant new patent gas-consuming air-tight stoves, require so small an amount of air to support combustion, that there is a strong probability of the occupants of a room thus heated smothering to death for want of fresh air, sooner or later, and generally the former.

A stove, if properly used, makes one of the most healthy and economical means of heating now known. There should always be a separate pipe for introducing the fresh air from the external atmosphere, which fresh and cold air should be discharged on or near the top of the stove. And if this supply of fresh air is abundant, with a constant evaporation of moisture sufficient to compensate for the increased capacity therefore due to the additional heat given it, and an opening into a heated flue near the ceiling, to be opened in the evening when the gas-lights are burning, or when the room is too hot, and kept shut at all other times, with another opening into a heated flue on a level with the floor, which should be kept *always open* to carry off the cold, heavy foul air from the floor—a stove thus arranged for many small isolated rooms, makes one of the most economical as well as most comfortable and healthy means of heating at our command. It combines the three great essentials necessary for comfort and health—*warmth*, partially by direct radiation, *fresh air* and *moisture*. But neither the open fire nor the stove, as desirable as they may be in many small rooms, are suitable for large rooms, especially where many persons are assembled. Heating principally by circulating warmed air, or in combination with direct radiation from exposed pipes filled with steam or hot water, is in such cases more convenient.

(To be continued.)

From the London Engineering, No 64.

HOW TO TAKE AWAY SHAKE IN SCREW STEAMERS.

We all know that screw steamers usually shake very much at the stern, and all this shaking cannot be accomplished without a waste of power, while it greatly impairs the comfort of passengers in the

ship. It will be useful to state, therefore, what the cause of this shake is, and how it may be remedied.

In the dynamometer applied to the *Rattler*, at the first introduction of the screw-propeller, it was found that each time the two-bladed screw came in the line of the stern-post, the thrust was momentarily increased, from the circumstance of the dead water in the rear of the stern-post, into which the screw then came, moving with nearly the same velocity as the ship, and the screw consequently for the moment acted upon it with nearly its whole velocity of rotation instead of the difference in the velocity of the screw and ship. Now, although in modern ships the stern-post is made too thin to drag much dead water after it, the skin of the ship drags a film after it, which the screw encounters at a certain part of its rotation, and action analogous to that which took place in the *Rattler* is thus induced. The main cause of the shaking at the stern is the inadequate size of the orifice in the dead wood in which the screw revolves. The screw, in revolving, carries a thick coating of water with it; and if the hole is only sufficiently large to allow the screw itself to revolve without this coating, it will follow that at each revolution the coating of water will be clipped over at the same time that this water strikes violently the sides of the dead wood and shakes the ship. One palliative is to enlarge the hole; another is to use a split screw, or two narrow screws, placed one immediately behind the other on the shaft, as in Mangin's arrangement; and the last and best is to carry the shaft through the rudder, and to allow the screw to revolve clear of everything, and astern of everything, at the extreme end of the ship. The rudder must, in such case,work in a frame, a boss in which will receive the end of the screw-pipe, and the screw itself will be overhung. The arrangement will be still easier if twin screws be employed; and those screws should be sunk as deeply in the water as possible, as the deeper they are,the less likely they are to be raised out of the water, and the less slip there will be.

GROUND BATTERIES.*

By Mr. A. G. Ballantyne, Electrician.

To the Members of the Franklin Institute.

Gentlemen: The subject that I have the honor of submitting for your consideration this evening, I think, is one of very considerable importance at the present stage of scientific research. Amongst

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* Abstract of paper read before the Franklin Institute, at the Stated Meeting, March 20th, 1867.

the various branches of the natural sciences, I have no doubt you will readily agree with me, that none has advanced so rapidly as that connected with electricity, that powerful and sublime agent which we perceive so impressively in the lightning and the thunder—that subtle and highly rarified element that pervades every atom of matter throughout our globe, and, in the twinkling of an eye, can send our thoughts to the utmost ends of the earth—deserves high appreciation, and untiring energy for its investigation.

The many appliances to which the electric fluid has already been adapted, (some of the highest importance to civilization and the general welfare of the human race,) show plainly how much has been done, while much more is yet to be done before we can arrive at the limits of its usefulness and power. Instruments have been contrived for diverting it from its latent condition, and other instruments, of very delicate workmanship, have been so constructed for detecting its presence when disturbed, that we are able to use it in many of the arts. As a motive power, it has been made to sustain, and even propel, many tons in weight. As an illuminating power, no artificial light ever yet discovered can equal it for brilliancy. As a chemical agent, nothing else in the laboratory can decompose an electrolyte, or, in other words, perform the various operations of analysis and synthesis so effectually as an uniform current of electricity.

For these different purposes, then, it is desirable that this fluid, or power, or principle, should be obtained with as little trouble and expense as possible, and to this particular end philosophers have directed their attention for many years. Professors of electrical science have propounded theories, and practical men have carried them out, as far as possible, in the construction of galvanic batteries, but, in my opinion, both have clung with too much tenacity to the original voltaic "*pile and crown of cups,*" invented many years ago by Volta, the Italian philosopher, whose name they bear, and up to the present day we have scarcely been able to get over the copper and the zinc excited by acid or saline solutions. Nor do I think we will ever get over the many difficulties with which we have to contend until we throw open wide the portals of that extensive storehouse—*the earth*, for an unlimited supply of electricity. As the first step in this direction, I beg to lay before you my experience in the construction of ground batteries, for generating a permanent current of galvanic electricity, uniform in its action, and of very considerable power, especially for any purpose where quantity is required, such as elec-

troplating or other decomposing operations. In every current of electricity, by whatever means it is produced, there are two peculiarities—quantity and intensity. These properties have been very ably discussed by Professor Morton in one of his lectures last winter, so that simply referring to the facts, that quantity is the actual amount of fluid produced, and intensity is the force with which that amount is passed through conductors, will be sufficient for my present purpose.

In 1846 I was in the employment of Mr. Alexander Bain, of Edinburgh, in Scotland, and superintended the laying of his one-wire telegraph from that city to Glasgow, a distance of forty-eight miles. The principle of this telegraph was, that the earth acted as one of the conductors, and the single wire, insulated on the tops of poles, as the other conductor, the termini of this wire being connected to metallic plates, sunk two or three feet into the ground, forming a complete circuit. While we were investigating the best method of connecting the ends of this long single wire with the earth, we found that various substances, excited by the moisture of the earth, not only acted as simple conductors, but generated a current of their own, contending slightly against a Smee's Battery we had in the arrangement for acting on the instruments, so that ultimately, to avoid this, we put a metallic plate, of the same kind, to each end of the wire.

Two or three years after this time, I had constructed a mechanical toy, in the form of an old man pumping water, to be worked by electro-magnetism, but one difficulty I had to keep the old man constantly moving, was a permanent battery. I thought of our experiments with the telegraph, and sunk a plate of zinc and a plate of copper, about two feet square, into a deep hole in the yard, and placed about eight inches apart, the space between being filled up with damp earth, and covered over with pavement, as before, two wires insulated with cord steeped in tar being brought from the plates into the house. This arrangement kept the little figure moving for more than three years, indeed until we were leaving the house. At this time I was anxious to know the condition of the plates, and on removing them I found the zinc quite clean, and very little changed, but the copper was much corroded, and so brittle that I did not take the trouble of lifting it all up.

The effects produced by the above observations led on to renewed efforts to obtain a permanent current of greater power. For this purpose I placed a basket of common coke (obtained at a gas works)

into a pond of water, with a plate of zinc in close proximity; a thick copper wire, No. 14, tied round a piece of the coke, and another piece of the same size soldered to the zinc. This arrangement acted with considerable power upon an electro-magnet, and with great uniformity for several months. This last experiment terminated in such a way that led to the final and most efficient method of constructing a permanent ground battery. The pond where the zinc and coke was deposited dried up during the summer, and left one-third of the two elements quite dry and exposed to the action of the atmosphere, while the other two-thirds of their surface remained buried in soft mud. I thought now that every trace of galvanic action must have ceased, but, to my astonishment, very little diminution of power had taken place. The apparatus I had for testing its power was a small electro-magnet, with its keeper fixed to the end of a lever, such as they use for weighing machines. By this simple arrangement the slightest difference of power can be detected.

The most complete form of this battery for permanency and uniformity of action, I will now explain in the following manner: A hole about four or five feet deep may be sunk in the ground, either in a cellar or out of doors, and about six feet in diameter. Then a sheet of zinc, about ten feet long and two feet eight inches wide, is to be bent round in the form of a tub without a bottom, and placed in this hole, about one foot from the sides. It will require, also, five or six bushels of coke to fill up the spaces outside and inside of the circular sheet of zinc. The process of packing may now be proceeded with. This operation requires the greatest care, so that no part of the zinc and coke can possibly come into contact with each other. The inside of the zinc cylinder is to be completely filled with coke, with a lair or stratum of damp earth placed between, about two inches in thickness. The same process is also to be performed outside of the zinc cylinder, using the same caution not to allow the smallest particle of carbon to come in contact with the zinc. This operation must be performed either with the hand or a small trowel. Two long thick copper wires, about No. 14, is now to be connected with these elements; the ends of the wires must be well tinned with a soldering bolt, about six or eight inches from the joining to the coke and zinc. The best method of connecting the wire to the coke is, to take one of the largest pieces of the coke, and insert the point of the tinned wire into one of its crevices, and then pour a little melted lead, from a ladle, very slowly round the end of the wire. By doing this, the lead will make metallic

contact with the tinned wire, and also run into every little interstice of the coke and completely cement it to it. A piece of coke prepared in this way is to be placed amongst the coke, on each side of the zinc, and connected together a little way from it; the wire making contact with the zinc may be soldered in the ordinary way. The two long wires must be perfectly insulated from their places of contact with the zinc and coke, both from each other and from the moisture of the surrounding earth. There are several ways of doing this, all equally efficient, but the one I adopted I consider the simplest, least expensive, and quite as successful as any of the other methods.

Take two copper wires, long enough to reach to your laboratory, or other place or places of operation. Insulate with cotton, then coat them over separately with black Japan varnish, such as photographers use for backing their positive glass pictures. When this coating has become firm, which will require about half an hour, twist the wires together their whole length, not very closely, but sufficient to keep them from separating; then give them another coating with the varnish, and when that has hardened, another coating; when, for greater security, a third may be applied. The conductors are now fit to be carried to any part of a building, always using pieces of leather or canvas where nails have to be used over walls or fences.

If this line of wires is required to be put in any public place where danger might be apprehended, it would be advisable to put it through a length or two of iron gas-pipe, high enough to be out of the reach of any person who might injure it, by accident or otherwise. We will suppose now we have reached the apartment where this battery is to be used,—nothing more has to be done but fix the ends of the wires to two binding screws, made fast in some convenient place, where two short wires may at any time be connected to them. Branches may be carried in this manner to every room in a building, from the main wires, but only one pair can be used at the same time. The amount of electricity evolved by the apparatus just described is never less in intensity and much greater in quantity than one pint cell of Daniell's arrangement in good action, and very often greater than two pint cells, which is quite sufficient for the majority of purposes to which galvanic electricity is applied. If a much weaker current is required than this arrangement evolves, its progress can be impeded by using iron or platinum wire, of the desired thickness, in connection with the terminal screws.

In conclusion, I would beg a few moments to make some remarks

upon the advantages of this battery for many purposes. The whole subject of electrical science is much simpler and less complicated than many people suppose, and all we have to get thoroughly acquainted with is, that there are but *two currents* that have ever been detected in any electrical, magnetic or galvanic series, and that these two currents have but two properties—*quantity* and *intensity*. These two currents have had various names given to them, such as positive and negative, anode and cathode, zincode and platinode, &c. Positive and negative are not very appropriate terms, as we have a current each way; anode and cathode, meaning the upward and downward way, is somewhat nearer; zincode and platinode has reference only to those two metals, and consequently not so good. The words *greater* and *less* would express their character more truthfully than either of the above—or, to make the terms more euphonious, we might say *major* and *minor* currents.

However, names are but secondary matters, so long as we understand what they mean.

The quantity and intensity of these two currents produce such a variety of effects upon different elements, that the student often mistakes their true character, and represents them as a variety of currents, whereas it is, in reality, different degrees of intensity of the same current. In the construction of some of those electro-magnetic machines for medical purposes, it is stated, they can give out six different currents. Now, from the nature and character of the electric fluid, it is simply an impossibility. Certainly, a machine may be constructed so as, from from the primary coil, a current is induced into the secondary coil, and from the secondary again into a third, and so on *ad infinitum;* but what does all this mean? It is only a different method of increasing the induced magnetic intensity. All this can be done by one secondary coil of greater length. Indeed, the tension of an induced magnetic current may be increased until it becomes identical with statical or frictional electricity. This statement is amply proved by the Ruhmkorff coil.

It has been stated by medical electricians, of the highest standing and undoubted authority, that a quantitative current passed through a primary coil, with just as much magnetic intensity as will pass it freely through the body, is the best form of application in disease. For this purpose, then, the Ground Battery is pre-eminently the best, on account of the extent of surface exposed and the quantity generated. Intensity can be increased in many ways, but quantity re-

quires exposure of a large surface with little excitement. This same rule holds good in the deposition of metals and all other decomposing operations. I have known one of those batteries depositing copper upon six vessels at the same time. There was a great demand for glass retorts, coated with copper, about ten years ago, in England, amongst manufacturing and experimental chemists. Many of those vessels were prepared by Messrs. Edwards & Wharrie, of Liverpool, by the electrotype process. They first coated over the glass vessel with tin-foil, in the same manner as a Leyden jar, on the outside; then immersed it in a solution of sulphate of copper in connection with a ground battery. This was the best one of the kind I had seen, and the last time I heard of it, it had been six years in operation, and was then quite as good as when first put into the ground. One feature I might mention here about this battery that I cannot account for very clearly—that is, that it improves in action, nearly one-half, for two or three weeks after it is put into the earth, and then remains quite steady and uniform. Time has not given me an opportunity of testing the durability of these batteries, but I have never known one of them to stop acting, except one, and there were very good reasons for that. A gentleman of my acquaintance put one into the earth, and when it was filled up deluged the whole place with several bucketsful of a strong solution of salt in water. The result was a very powerful action at first, but gradually diminished, till, at the end of five or six months, a galvanometer could scarcely detect the slightest trace. Nothing but the moisture of the earth itself must be used, and good effects will be the consequence.

Those who are interested in the progress of galvanic science, and have the means and opportunity of investigating this subject, would some day confer a lasting obligation upon the world in supplying a *motive power*, an *illuminating power*, and a *decomposing power*, at a mere nominal expense, and superior to anything ever yet invented or discovered.

The above remarks are from my own observation and experience, so that I can guarantee their truthfulness, and with much pleasure hand them over to the members of the Franklin Institute, if thought worthy of their acceptance.

From the London Engineering, No. 64.

BLACKWALL ROCK AND ITS LESSONS.

THERE is a part of the river Thames, immediately above Blackwall Stairs, and below the entrance to the West India Docks, where an eddy of the stream accumulates a shoal through which some agglutinating springs rise that convert the sand into rock, which has occasionally to be blasted. In 1838, when the vessels of the Peninsular Steam Company sailed from Blackwall, this rock attracted Mr. Bourne's attention, as it incommoded the vessels with which he was then concerned; and having observed the nature of the phenomenon, he saw that it might be artificially imitated with advantage in certain difficult engineering works, and he treasured up the recollection in his memory for future guidance.

In 1847, Mr. Bourne went to India with Sir Macdonald Stephenson, as one of the engineers of the East India Railway, and among the works which had to be constructed was a bridge over the river Soane, in length nearly equal to the Blackwall Railway, and with a foundation of quicksand as deep as borings had extended. Here it appeared to Mr. Bourne was a case for the application of the lesson he had learned from Blackwall, and he at once proposed to surmount the difficulty of foundations by converting the quicksand into rock to such an extent as would give the necessary stability to the superstructure. A hill of iron pyrites lay near at hand, and Mr. Bourne proposed to sink perforated pipes into the quicksand, and to inject into it through them a sufficient quantity of iron water to stick together the whole mass. Here would be an artificial production of rock, imitating its natural production at Blackwall.

In 1848, the progress of the East India Railway was arrested by financial difficulties, and when the work was eventually resumed, the direction of the line was altered so as to proceed up the valley of the Ganges, instead of adopting the line of the trunk-road, as the Government commission had recommended. The Soane, consequently, was not crossed eventually at the place originally proposed, but much lower down, and the foundations were obtained by sinking wells in the way usually adopted in Indian works. As executed, the Soane Bridge is the longest bridge in the world, that of the St. Lawrence alone excepted, and it has been constructed by Mr. Turnbull in a most efficient and successful manner, and constitutes a great monument of his engineering ability. But the difficulties of the work would have been lessened and its cost reduced if the foundations had been laid upon artificial rock, as Mr. Bourne had some years before proposed. We have no doubt that this resource will hereafter become a valuable feature in engineering, as it enables us to reduce enormously the cost and difficulty of constructing secure foundations in treacherous ground.

discharging rods, furnished with balls of different diameters and points, are connected by wires (covered by insulating material if desirable) to the balls of the combs. Any desired combination can easily be made. Either of the sectors or combs, with its connections can at pleasure be removed, or their distance to the revolving plate adjusted.

The relative positions of the parts are held with great firmness.

The presence of the stationary plate, near the revolving one, adds to its insulation, and in this way to the efficiency of the machine. In other respects, the advantages sought are simplicity of construction and stability of the parts. The insulation of the supporting plate, allows the discharges to be brought nearer the revolving plate, and avoids disturbing influences from one to the other, and allows the machine to be much more compact in form.

We take upon ourselves the responsibility of publishing the following letter which Mr. Ritchie has sent us with permission to use; but with the expression of doubts as to the wisdom of making it public, because of the many anamolies in this machine, and the interruption of his experiments, by reason of which they have been less numerous and extended than he could have wished. We regard the results reached, however, as so interesting, and the field so full of promise to all who may be led to cultivate it, that a little risk may well be run of having to modify some deduction in future. Mr. Ritchie's reputation in matters of electrical science, is, moreover, such as to enable him to correct himself with good grace, should any of his present conclusions require modification in future.

Prof. Morton.

DEAR SIR: It is with some hesitation, that I send you the result of some experiments, made with view of determining the electrical condition of the different portions of the revolving plate of the Holtz machine; but which experiments were interrupted before I had verified the results as I wish to do.

I removed the two upper sectors of my machine, leaving two at 90° apart, thus leaving nearly three-fourths of the plate between the sectors on one side. From this portion I removed every conductor as far as possible; still, the machine, in action, is surrounded by *such an atmosphere* of electricity, that there is danger of being deceived in the results sought.

I took proof planes of two and three inches diameter, with lac handles, to take the charge and bring to the gold leaf electrometer, stopping the plate suddenly, and applying the proof planes—sometimes to both sides and sometimes on one side, simultaneously, or alternately. They *in general*, indicated opposite electricities and different intensity

in opposite sides of the plate; yet, in a large number of trials, made as nearly as possible in the same place relatively to the sectors, the results were so contradictory that nothing could be determined,—sometimes the one side was positive, sometimes negative.

I then applied the proof plane on one side and a disc of metal of larger diameter to the opposite side in connection with the earth, thus leaving the electricity on the side of the proof plane free, and by repeating many times the experiment in the same place, on both sides, I was surprised to find both sides of the revolving plate of the same kind in all cases; *negative* when the preceding sector had been excited *positive*.

The two sides of the sectors, when removed, show also the same kind.

The role of the papers upon the sectors is far from clear; they may be on either or both sides of the glass. On a number, made as nearly alike as possible, a few may act well; the varnish of some may be scratched even through the paper in all directions, and with slight loss of effect. Others may resist all excitation, but, by doubling a piece of tin-foil over the edge, may perform well.

The paper may be left off entirely, and a piece of tin-foil doubled over the edge, as large on each side as the paper is usually made, retaining a card-point *feeder*, without varnish, and yet this may do very well for at least one of the sectors where only a pair is used.

The power of the instrument for evolving ozone is very great, and I have reason to caution those using the machine in a confused atmosphere.

Very respectfully, yours,

E. S. Ritchie.

From the London Mechanics' Magazine, January, 1867.

(Continued from page 263.)

ON SOUNDING AND SENSITIVE FLAMES.

By Professor Tyndall.

Another flame is now before you. It issues from a burner, formed of ordinary gas-tubing by my assistant. The flame is 18 inches long, and smokes copiously. I sound the whistle; the flame falls to a height of 9 inches, the smoke disappears, and the brilliancy of the flame is augmented. Here are two other flames, also issuing from burners formed by my assistant. The one of them is long, straight, and smoky; the other is short, forked, and brilliant. I sound the whistle; the long flame becomes short, forked, and brilliant; the forked flame becomes long and smoky. As regards, therefore, their response to the sonorous waves, the one of these flames is the exact

complement of the other. Here are various flat flames, 10 inches high, and about 3 inches across at their widest part. They are purposely made forked flames. When the whistle sounds, the plane of each flame turns ninety degrees round, and continues in its new position as long as the whistle continues to sound.

Here, again, is a flame of admirable steadiness and brilliancy, issuing from a single circular orifice in a common iron nipple. I whistle, clap my hand, strike the anvil, and produce other sounds, the flame is perfectly steady. Observe the gradual change from this apathy to sensitiveness. The flame is now 4 inches high. I make its height 6 inches; it is still indifferent. I make it 10 inches, a barely perceptible quiver responds to the whistle. I make it 14 inches high, and now it jumps briskly the moment the anvil is tapped or the whistle sounded. I augment the pressure, the flame is now 16 inches long, and you observe a quivering which announces that the flame is near roaring; I increase the pressure; it now roars, and shortens at the same time to a height of 8 inches. I diminish the pressure a little; the flame is again 16 inches long, but it is on the point of roaring. It stands as it were on the brink of a precipice. *The whistle pushes it over.* Observe it shortens when the whistle sounds, exactly as it did when the pressure was in excess. The sonorous pulses, in fact, furnish the supplement of energy necessary to produce the roar and shorten the flame. This is the simple philosophy of all these sensitive flames.

The pitch of the note chosen to push the flame over the brink is not a matter of indifference. I have here a tuning-fork, which vibrates 256 times in a second, emitting a clear and forcible note. It has no effect upon this flame. Here are three other forks, vibrating respectively 320, 384, and 512 times in a second. Not one of them produces the slightest impression upon the flame. But, besides their fundamental notes, these forks can be caused to sound a series of overnotes of very high pitch. I sound this series of notes: the vibrations are now 1600, 2000, 2400, and 3200 per second respectively. The flame jumps in response to each of these notes; the response to the highest note of the series being the most prompt and energetic of all. To the tap of a hammer upon a board the flame responds; but to the tap of the same hammer upon an anvil the response is much more brisk and animated. The reason is, that the clang of the anvil is rich in the higher tones to which the flame is most sensitive. Here, again, is an inverted bell, which I cause to sound by means of a fiddle-bow, producing a powerful tone. The flame is unmoved. I bring a half-penny into contact with the surface of the bell; the consequent rattle contains the high notes to which the flame is sensitive. It instantly shortens, flutters, and roars when the coin touches the bell.

Here is another flame 20 inches long. I take this fiddle in my hand, and pass a bow over the three strings which emit the deepest notes. There is no response on the part of the flame. I sound the highest string: the jet instantly squats down to a tumultuous bushy

flame, 8 inches long. I have here a small bell, the hammer of which is caused to descend by clockwork. I hold it at a distance of 20 yards from the flame. The strokes follow each other in rhythmic succession, and at every stroke the flame falls from a height of 20 inches to a height of 8 inches.* The rapidity with which sound is propagated through air is well illustrated by these experiments. There is no sensible interval between the stroke of the bell and the shortening of the flame. Some of these flames are of marvellous sensibility; one such is at present burning before you. It is nearly 20 inches long; but the slightest tap on a distant anvil knocks it down to 8 inches. I shake this bunch of keys or these few copper coins in my hand; the flame responds to every tinkle. I may stand at a distance of 20 yards from this flame; the dropping of a sixpence from a height of a couple of inches into a hand already containing coin, knocks the flame down. I cannot walk across the floor without affecting the flame. The creaking of my boots sets it in violent commotion. The crumpling of a bit of paper, or the rustle of a silk dress, does the same. It is startled by the plashing of a raindrop. I speak to the flame, repeating a few lines of poetry; the flame jumps at intervals, apparently picking certain sounds from my utterance to which it can respond, while it is unaffected by others.

In our experiments, downstairs, we have called this the vowel flame, because the different vowel sounds affect it differently. Vowel sounds of the same pitch are known to be readily distinguishable. Their qualities or clang-tints are different, though they have a common fundamental tone. They differ from each other through the admixture of higher tones with the fundamental. It is the presence of these higher tones in different proportions that characterises the vowel sounds, and it is to these same tones, and not to the fundamental one, that our flame is sensitive. I utter a loud and sonorous U, the flame remains steady; I change the sound to O, the flame quivers; I sound E, and now the flame is affected strongly. I utter the words *boot*, *boat* and *beat* in succession. To the first there is no response; to the second, the flame starts; but by the third and fourth it is thrown into violent commotion; the sound *Ah!* is still more powerful. When the vowel sounds are analyzed their constituents are found to vary in accordance with the foregoing experiments; those characterised by the sharpest overtones being the most powerful excitants of the flame.

The flame is peculiarly sensitive to the utterance of the letter S. If the most distant person in the room were to favor me with a "hiss," the flame would be instantly shivered into tumult. The utterance of the word "hush," or "puss," produces the same effect. This hissing sound contains the precise elements that most forcibly affect the flame. The gas issues from its burner with a hiss, and an external

* The bell was carried into the gallery of the theatre, and from that distance produced instantaneously the same effect on the flame.

sound of this character added to that of a gas-jet already on the point of roaring is equivalent to an augmentation of pressure on the issuing stream of gas. I hold in my hand a metal box containing compressed air. I turn the cock for a moment, so as to allow a puff to escape—the flame instantly ducks down, not by any transfer of air from the box to the flame, for I stand at a distance which utterly excludes this idea; it is the *sound* of the issuing air that affects the flame. The hiss produced in one orifice precipitates the tumult at the other.

[We may state for the information of readers who may wish to repeat any of the interesting experiments described by Dr. Tyndall that the one thing necessary to their success is to have the gas delivered with a steady equable pressure. The lecturer made use of a small gasometer, and did not depend on the ordinary service pressure, which is liable to frequent fluctuations.—Ed. M. M.]

THE ZENTMAYER LENS.

In the *Philadelphia Photographer* for May, just received, we find the report of a committee appointed by the Photographic Society, of this city, to make a thorough examination of this lens.

We extract the important results embodied in this report without giving preliminary remarks and general explanations.

"The first experiment was a trial between a 12-inch globe lens, and a Zentmayer of nearly the same focal length.

"In precise terms the Zentmayer lens was 12 inches in focal length, the globe 12·94 inches. The stop used in the globe was $\frac{24}{100}$ths of an inch. That used in the Zentmayer was $\frac{22}{100}$ths of an inch, which were in the following proportions to the focal lengths: Globe, *f*, 53·92; Zentmayer, 54·54."

"The circles of light," (on the ground glass, Ed.,) "were found by measurement to be 22·8 inches.

"The day was favorable, and an exposure of forty-five seconds was given to each plate. The negatives were equally well exposed.

"In definition and evenness of illumination, there was manifest a decided superiority in the negative by the Zentmayer lens."

(Though it is not mentioned in the report, we know from members of the committee that the focusing and exposure were both conducted with the same stop in the Zentmayer as well as in the globe lens.—Ed.)

"The committee then made pictures with the Zentmayer lens of 18 inches focal length on plates 18 by 24 inches."

The stop here used to expose was $\frac{1}{15}$th of the focal length, a larger one being employed for focusing.

"The result surpassed the expectations of all present. The instrument possesses all the qualifications which constitute excellence in a lens.

"Upon careful examination no difference could be found between the visual and actinic focus."

We have seen many pictures taken with these lenses, and can fully confirm the opinion expressed by the committee that "all the qualifications constituting excellence are possessed by this lens," and that it has a combined extent of angle, flatness of field and depth of focus possessed by no other existing combination.

This lens was first exhibited in public, at the meeting of the Franklin Institute for June, 1866, when it was fully described in the Secretary's report, (see this *Journal*, Vol. LII., page 63.) Our able contemporary, the *British Journal of Photography*, took, with reference to this matter, the strange ground that the lens described must, on theoretical grounds, be inaccurate, especially with reference to want of coincidence in the chemical and luminous foci, and that, therefore, such a lens could not possibly produce the effects stated.

Such *a priori* assertion (we cannot call it reasoning) in opposition to fact, we did not consider it worth while to notice. We could well afford to wait until time and better knowledge should vindicate the truth. Overwhelming testimony at last appears to have convinced our critic that facts could not so easily be disposed of on theoretical grounds. He, however, still tries to force fact into accordance with his theory, and by new assumptions to depreciate the merits of this invention which has the misfortune to operate in opposition to his judgment.

In justice to the inventor we feel called upon to say, that all the new assumptions are as far from the fact as the first one, and that this lens is, beyond doubt, destined to achieve as wide a reputation as the world-renowned American globe lens, (which, as may be noticed in the report above, it excels,) and which, like it, was at first rediculed in the foreign press as an impossibility.

FACTS AND FIGURES IN REGARD TO THE PENNSYLVANIA RAILROAD.

By J. M. Wilson, C.E., Principal Assistant Engineer P. R.R.

We submit to our readers the following interesting statistics furnished through the kindness of Mr. Wilson, from whom we are pro-

mised some other valuable information concerning the new bridges on the same road. ED.

LENGTH OF MAIN LINE FROM PHILADELPHIA TO PITTSBURGH, INCLUDING HARRISBURG AND LANCASTER RAILROAD *via* MOUNT JOY.

1.—*Track.*

	Miles.	Tenths.
From west end Market Street Bridge to Passenger Station, West Philadelphia	0	2
From Passenger Station, West Philadelphia, to Harrisburg	105	5
From Harrisburg to Passenger Station, Pittsburgh	248	2
From Passenger Station, Pittsburgh, to Duquesne Depot		9
	354	8
Length of road *via* Columbia	358	7
Distance from Passenger Station, West Philadelphia, to Passenger Station, Pittsburgh, *via* Mount Joy—distance travelled, by through passenger trains	353	7
Length of double track, Main line	348	9
Amount of double track yet to be laid, to give continuous double track from Philadelphia to Pittsburgh	5	9
Length of sidings on Main line	121	2

BRANCH ROADS OWNED BY PENNSYLVANIA RAILROAD.

Hollidaysburg Branch	7	6
Indiana "	19	0
Delaware Extension	5	5
Steubenville "	1	2
	33	3

ROADS LEASED BY PENNSYLVANIA RAILROAD.

East Brandywine and Waynesburg	17	0
Harrisburg and Lancaster	54	1
Mifflin and Centre County	6	9
Tyrone and Clearfield	23	5
Bald Eagle Valley	51	2
Ebensburg and Cresson	11	0
Western Pennsylvania Railroad	63	7
Philadelphia and Erie "	287	5
	514	9

AMOUNT OF SINGLE TRACK OPERATED BY PENNSYLVANIA RAILROAD.

Main line	729	3
" sidings	121	2
Branches, including sidings	603	9
Total single track	1554	4

Which, if extended out by shortest present railroad route, would reach from Philadelphia to fifty miles beyond Fort Kearney, N. T., or if laid as one continuous rail, would reach one-eighth around the world.

The road had laid in track January 1st, 1867, over 2000 tons of steel rails, of which some 1500 tons are laid in main tracks, and the balance in sidings. About 250 tons are crucible steel, the balance are Bessemer steel. They are wearing remarkably well. At some points where the above rails have been in use, two or three sets of iron would have worn out, while the steel rails are yet in good condition.

2.—*Tunnels—Main Line.*

There are eight tunnels in Main Line, of the following lengths: 200, 900, 1200, 3612. (Alleghany Mountain,) 650, 300, 450 and 450 feet.

Total lineal feet of tunnelling, 7762 feet.

3.—*Stations on Main Line.*

Passenger	85
Freight	52

4.—*Engine Houses—Main Line.*

West Philadelphia—No. 1	21	engines capacity.
" No. 2	44	"
Columbia	20	"
Harrisburg	44	"
Mifflin	15	"
Altoona	30	"
"	26	"
"	44	"
Conemaugh	15	"
Pittsburgh	44	"
Miscellaneous points on road	11	"
Total	314	"

The Company is now putting up an engine house at Pittsburgh for 40 engines, and contemplates building one at Harrisburg for 44 engines, which will give a total capacity of 396 engines.

5.—*Shops—Main Line.*

There are eight principal shops on Main Line, comprising a total superficial area of buildings of over ten acres actually under roof, exclusive of engine houses and all buildings, except *shops proper.*

6.—*Bridges—Main Line.*

Number of iron bridges, Main Line	141
" wooden " "	48
" stone " " of 24 feet span and upwards,	17
Total length of iron bridges	12,097 feet.
" wooden "	8,595 "

The Company has now under construction and will bring into use this year, 1408 feet lineal of iron bridges. This will alter the above items, giving us

Total length iron bridges	13,505 feet.
" wooden "	7,187 "

7.—*Motive Power, January 1st, 1867, exclusive of Philadelphia and Erie Railroad.*

Passenger Engines	72
Freight "	230
Switching "	37
Constructing "	23
Total	362

8.—*Passenger and Freight Equipment, Jan. 1st, 1867, exclusive of Philadelphia and Erie Railroad.*

Passenger Cars	147
Emigrant "	44
Baggage "	43
Mail "	4
Express "	38
Box "	2711
Stock "	995
Gondola "	2072
Coal "	2204
Oil "	50
Total	8308

9.—*Mileage made by Engines during 1866, exclusive of Philadelphia and Erie Railroad.*

Passenger Engines	1,775,472
Freight and Switching Engines	5,304,554
Constructing	273,240
Total	7,353,266

It will be noticed particularly, that items 2, 3, 4, 5 and 6 are for *Main line* only, and items 7, 8 and 9 do not include Philadelphia and Erie Railroad. If the engines and cars given in items 7 and 8 were coupled together on one track, they would make a train nearly sixty miles long. The mileage given in item 9 is equivalent to that of one engine running nearly 296 times around the earth.

EDUCATIONAL

(Continued from page 284.)

MAGIC LANTERN

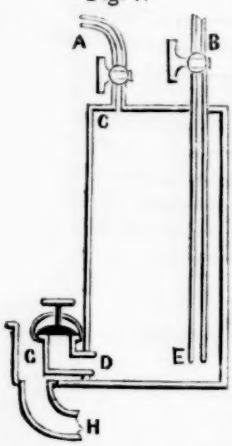
AS A MEANS OF DEMONSTRATION.

Methods of Storing Gas Continued.

PROF. OGDEN DOREMUS, of New York, has for many years employed an arrangement which, as a fixture, has many features of convenience, simplicity and efficiency.

The apparatus is indicated in outline by Fig. 7. In this, C D E represents a large cylindrical vessel, of sheet-copper or iron, say of six feet in height and three feet in diameter, (which would give a capacity of about 330 gallons.) This has two openings above, one, A, for the escape of gas, the other, B, for the admission of water, which is received from a reservoir or tank, placed at a convenient height, to secure a sufficient and not too heavy pressure. An opening, D, below is arranged on the bird-fountain principle, so as to allow a tube, delivering gas, to be introduced, and the water at the same time to pass out into the exterior basin, C, from which it escapes by a discharge-pipe, H, and is carried off by appropriate conduits out of the building. The upper openings are controlled by stop-cocks, this lower one is provided with a cap, as indicated, which is fastened with a screw clamp.

Fig. 7.



To manipulate this apparatus, the opening D is closed, while A and B are opened, the water entering by B, and air escaping through A. When the cylinder has thus been filled with water, A and B are closed, the cap is removed from D, and the end of the tube which delivers gas, from the retort or other apparatus used to develop it, is introduced through D, and the gas is thus collected, the water escaping as it is displaced. When all the gas desired has thus been introduced, D is again closed by its cap, connections are made between A and the ap-

paratus to be employed, and the cock B being opened, the gas is expelled as required, by the hydrostatic pressure of the water from the reservoir. A glass gauge is of great use with this apparatus, and may be easily attached by having two openings in the side of the cylinder, one near each end, (provided with stop-cocks in case of accident,) and connecting them by a glass tube, the joints being made with short pieces of rubber hose.

The dimensions stated above are very large, and are those of the two cylinders employed by Dr. Doremus, at the City College. At the Bellevue Medical College, the Doctor uses a smaller pair, and, of course, the size may be varied to suit all conditions. A moderate and regular head of water may also be obtained by the use of a small tank, with a ball-cock regulating its supply from the service-pipe; while further, to obtain uniformity in pressure, the cylinder may be placed not vertically but horizontally.

Grant's Gas Reservoirs.

The plan devised and carried out by Mr. Robert Grant, of New York, for storing gas, under heavy pressure, in strong iron cylinders, is one which, under certain conditions, possesses unparalleled advantages. The cylinders used are nine inches in diameter, of sheet iron one-sixteenth of an inch thick, and being about two and a half feet long, are closed by heads of $\frac{1}{8}$-inch iron, so corrugated as to give them additional strength, and are further secured by a stay-bolt, which occupies the axis of the cylinder. This bolt itself consists of a piece of $\frac{1}{2}$-inch heavy gas pipe, and at one end terminates in the stop-cock, which consists of a conical steel plug, forced, by a fine-threaded screw, on its own shaft, into a brass or iron seat. In size and taper, this plug or valve much resembles the point of a pencil case. It makes a valve, which may be easily rendered absolutely tight, and opened with great delicacy of graduation; a point of much importance with the high pressures employed, which, with any valve liable to be suddenly opened, would produce much such effects as are obtained with an air gun.

These cylinders are charged with the gas by means of a powerful condensing pump, run by steam, and are capable of safely resisting a pressure of twenty to thirty atmospheres. Their weight is about twenty-six pounds, and capacity one cubic foot; when fully charged, therefore, they will contain thirty cubic feet, or about two hundred and twenty-four gallons of gas, or about as much as seven pounds of

chlorate would yield, and as much as would fill between five and six 30 by 40 inch gas bags to their good working capacity. The gas adds but a small weight, (about two and a half pounds for oxygen, and half this for burning gas,) and a boy may thus move from place to place a quantity of gas which, stored in any other way, would fill a wagon.

The merits of the system lie precisely in this, and are expressed in the words "ease of transportation."

In some cases it is desirable to employ a regulator for the outflow of the gas, by which its pressure may be restrained within narrow limits, and at a moderate amount from first to last, in a connected apparatus. Such a regulator, of a very efficient character, has been devised by Mr. Grant, and consists of one of the conical valves mentioned above, whose motion is controlled by a flexible diaphragm. One of these, which I have used for many months, operates in the most satisfactory manner.

(Continued from page 282.)

LECTURES ON ELECTRICITY AND LIGHT.

Delivered before the Franklin Institute, by Prof. Henry Morton, Ph.D.

Before the invention of improved instruments, (such as the Induction Coil,) by which an almost unlimited quantity of electricity can be easily obtained, large machines were much valued by reason of the above properties, and when Winter, of Vienna, advertised at very moderate prices, machines which were warranted to give sparks of extraordinary length, much wonder was excited among all conversant with the subject, as to the means by which such results could be reached.

Thus, he offered a machine capable of throwing a spark of two feet for $150, while that of Von Marum, before mentioned, gave no more than this and could not have cost much less than that of Mr. Ritchie, shown in our last number, and valued at $3000. In smaller machines, Winter's prices were equally remarkable. Thus, for $50, one was furnished capable of yielding sparks of from 12 to 14 inches; and for $25 one of 7 to 9 inches spark length; while, omitting other intermediate sizes, the smallest, offered for *six dollars*, gave sparks of 2 to 3 inches.

The reason of this anomaly soon appears on view of these machines. They are not larger than those of a *corresponding price* furnished by other makers; but they are all provided with a special contrivance by which their spark length is greatly increased. This contrivance consists of a large ring of dry polished wood (see Fig. 8) containing within it a wire which extends down the upright by which this is supported in the prime conductor, as shown in the cut. The prime conductor is in this case only a hollow ball. The diameter of the ring for the $25 machine (which has a plate of 15 inches diameter) is two feet, and for the other machines in proportion.

Fig. 8.

9 $\frac{1}{10}$

The structure of this machine is not, in other respects, remarkable. It is shown at Fig. 9 without the ring above described, which would be set by its stem in the prime conductor, *a*.

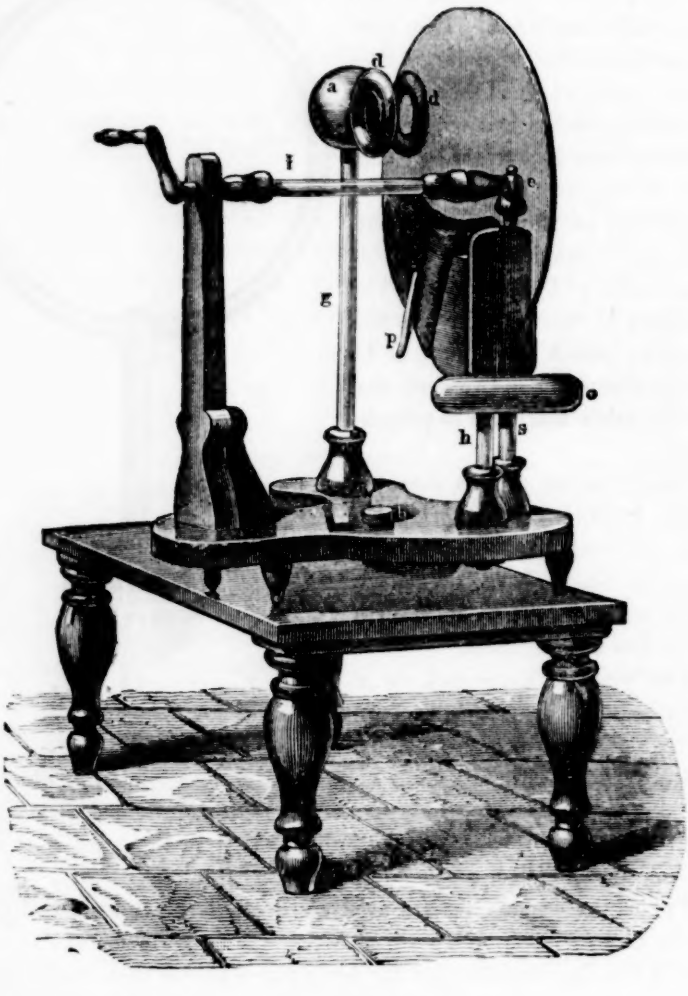
The plate is supported on a glass axle, *i*, the rubber is supported below on the glass upright, *h*, and terminates in silk flaps kept in place by nippers, *p*, when the machine is not in use. Two wooden rings, *d d*, provided with needle points on their interior surfaces, and coated in the same part with tin-foil, act as collectors.

Two of these machines are used by Prof. R. E. Rogers, and yield excellent results.

It is but fair to state that for some years before these machines of Winter's were announced, Mr. Trautwine, whose reputation as a civil engineer is so widely extended, had used a glass jar filled with metal foil as a means of adding length to the spark of an ordinary machine, which result it effects with great convenience and success.

A glass globe, internally silvered, such as is attached to their machines by Messrs. Queen & Co., of this city, is an effective and elegant modification of the same principle.

Fig. 9.



ERRATUM.

Description of Parhelium Observation at Germantown, on page 277, should read *February*, 1867, and not *February*, 1865.

Bibliographical Notice.

General Problems of Shades and Shadows. By S. Edward Warren, C. E., Professor of descriptive geometry, &c., in the Renssalaer Polytechnic Institute. Published by John Wiley & Son, New York.

The work named above is one of great value to the practical draftsman, engaged in the execution of mechanical drawings for machinery or engineering structures, where accuracy of detail is of the first importance, and where the correct delineation of a shadow may be quite impossible in many cases, without the knowledge which the study of this book will give him.

To the architect, in an even greater degree, such a work will be of use, for with him the arrangement of his design must be in no small extent controlled by the effect which will be developed in the finished work by the "shades and shadows," which it will project within itself.

To the artist this will be of less importance, for it is the prerogative of his genius to convey the spirit of nature, not so much by accurate imitation, as by a poetic idealization of her forms. There is, however, a large class of able artists to whom, nevertheless, the above work will be of great value, and what with those whom we have enumerated, and others who might be added to the list, we should expect a pretty good demand for the work in question.

When we first opened the book and found fifteen large plates, which, though not "beautiful," (being geometrical projections simply,) are very well and carefully engraved on stone, and are, in many cases, very complicated; we were surprised to see that a publisher had been found so venturesome as to undertake such a work, but, on reading the preface, (the utmost which should be expected of a reviewer,) the mystery was explained by the statement, that "this expensive volume now appears through the kindness of students of the institute, in making up a liberal subscription in aid of its hitherto delayed publication."

In fine, this work on Shades and Shadows is a descriptive, geometrical treatise, explaining the methods to be pursued in projecting shadows of all kinds of objects, upon surfaces of all descriptions of curvature; and knowing this, all who want such a work will know that also, and, moreover, where to get it.

A COMPARISON *of some of the Meteorological Phenomena of* MARCH, 1867, *with those of* MARCH, 1866, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11½′ W. from Greenwich. By PROFESSOR J. A. KIRKPATRICK, of the Central High School.

	March, 1867.	March, 1866.	March, for 16 years.
Thermometer—Highest—degree.	61·50°	72·00°	78·50°
" date.	31st.	15th.	3d, '61.
Warmest day—mean ..	53·00	62·00	66·00
" " date.	31st.	15th.	3d, '61.
Lowest—degree .	20·00	26·00	4·00
" date .	15th.	18th.	10th, '56.
Coldest day—mean .	25·67	28·50	11·50
" " date .	18th.	26th.	16th, '56.
Mean daily oscillation...	12·64	13·84	14·54
" " range.	5·03	7·37	6·14
Means at 7 A. M.	34·14	37·18	35·84
" 2 P. M.	41·29	45·43	46·51
" 9 P. M .	37·32	40·85	40·35
" for the month....	37·58	41·15	40·90
Barometer—Highest—inches.	30·485	30·199	30·522
" date.	15th.	1st.	3d, '52.
Greatest mean daily pressure	30·450	30·156	30·450
" " " date...	15th.	1st.	15th, '67.
Lowest—inches .	29·430	29·485	29·158
" date.	2d.	16th.	17th, '54.
Least mean daily pressure...	29·523	29·538	29·241
" " " date...	2d.	16th.	22d, '65.
Mean daily range.	0·235	0·161	0·194
Means at 7 A. M	30·032	29·893	29·855
" 2 P. M	30·002	29·822	29·800
" 9 P. M	30·015	29·862	29·836
" for the month	30·016	29·859	29·830
Force of Vapor—Greatest—inches .	0·333	0·438	0·549
" date .	1st.	15th.	18th, '59.
Least—inches.	·060	·066	·023
" date.	29th.	17th.	5th, '58.
Means at 7 A. M	·154	·173	·165
" 2 P. M	·159	·190	·179
" 9 P. M	·161	·193	·181
" for the month...	·158	·185	·175
Relative Humidity—Greatest—per cent	95·0	95·0	100·0
" date.	6th.	21st.	Often.
Least—per cent....	23·0	29·0	16·0
" date.	29th.	30th.	31st, '60.
Means at 7 A. M....	76·1	71·9	73·5
" 2 P. M....	60·2	57·8	53·8
" 9 P. M....	71·7	69·4	68·0
" for the month	69·3	66·4	65·1
Clouds—Number of clear days*.	7·	8·	9·5
" cloudy days .	24·	23·	21·6
Means of sky covered at 7 A. M	75·1 per ct	60·0 per ct	61·0 per ct
" " " 2 P. M	74·2	73·6	63·4
" " " 9 P. M	61·9	53·9	47·7
" " for the month	70·4	62·5	57·4
Rain and melted snow—Amount—inches	5·670	2·035	3·419
No. of days on which rain or snow fell...	18·	11·	11·3
Prevailing Winds—Times in 1000.	N 7° 51′ E·340	N58°14′W·294	N65°32′W·267

* Sky one-third or less covered at the hours of observation.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LIII.] JUNE, 1867. [No. 6.

EDITORIAL.

Engineering Items.

Transmitting power with economy.—Methods of applying mechanical force which are not, on general principles, economical, may, notwithstanding, from special conditions involved in particular cases, be highly useful and practically thrifty. Such, for example, would seem to be the case with the various "hoists" in which hydraulic presses are caused to operate what we might call inverted "mechanical powers," and of which so many examples are now presenting themselves in the world of mechanical invention. In all these, a high velocity in the pumping engine is converted into a low one in the press, only to be again reconverted into a rapid movement in the application to the machine. This change implies a loss incurred in the various intermediate machines; but the convenience of transmitting the power by this means, in certain cases, compensates for all. The power is, we may say, condensed for transportation, and expanded when it gets to its work. This is the very reverse of the method which has received the name of Teledynamic, (τῆλε far off, δύνάμις power,) where the force is transmitted at high velocities by very light running parts. An ex-